**3GPP TSG RAN WG1 Meeting #110-bis-e R1-2210619**

**e-Meeting, October 10 – 19, 2022**

**Source: Moderator (Intel Corporation)**

**Title: Discussion Summary #3 for energy saving techniques of NW energy saving SI**

**Agenda item: 9.7.2**

**Document for: Discussion**

# Introduction

In this contribution, moderator summarizes discussions on remaining issues related to potential solutions for network energy saving SI from RAN1 #110-bis-e. SI objectives agreed in RP-220297 is shown below for reference.

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| The objectives of the study are the following:   1. Definition of a base station energy consumption model [RAN1]  * Adapt the framework of the power consumption modelling and evaluation methodology of TR38.840 to the base station side, including relative energy consumption for DL and UL (considering factors like PA efficiency, number of TxRU, base station load, etc), sleep states and the associated transition times, and one or more reference parameters/configurations.  1. Definition of an evaluation methodology and KPIs [RAN1]  * The evaluation methodology should target for evaluating system-level network energy consumption and energy savings gains, as well as assessing/balancing impact to network and user performance (e.g. spectral efficiency, capacity, UPT, latency, handover performance, call drop rate, initial access performance, SLA assurance related KPIs), energy efficiency, and UE power consumption, complexity. The evaluation methodology should not focus on a single KPI, and should reuse existing KPIs whenever applicable; where existing KPIs are found to be insufficient new KPIs may be developed as needed.   Note: WGs will decide KPIs to evaluate and how.   1. Study and identify techniques on the gNB and UE side to improve network energy savings in terms of both BS transmission and reception, which may include:  * How to achieve more efficient operation dynamically and/or semi-statically and finer granularity adaptation of transmissions and/or receptions in one or more of network energy saving techniques in time, frequency, spatial, and power domains, with potential support/feedback from UE, and potential UE assistance information [RAN1, RAN2] * Information exchange/coordination over network interfaces [RAN3]   Note: Other techniques are not precluded  The study should prioritize idle/empty and low/medium load scenarios (the exact definition of such loads is left to the study), and different loads among carriers and neighbor cells are allowed.  The following example scenarios (mapping between scenarios and network loads is left to the study) including single-carrier and multi-carrier deployments are used as the starting point for discussion on prioritized scenarios for the study.  The following example scenarios are listed in no particular order.   * Urban micro in FR1, including TDD massive MIMO (note: this scenario can also model small cells) * FR2 beam-based scenarios (note: this scenario can also model small cells) * Urban/Rural macro in FR1 with/without DSS (no impact to LTE expected in case of DSS) * EN-DC/NR-DC macro with FDD PCell and TDD/Massive MIMO on higher FR1/FR2 frequency   Note 1: legacy UEs should be able to continue accessing a network implementing Rel-18 network energy savings techniques, with the possible exception of techniques developed specifically for greenfield deployments.  Note 2: the study of energy savings specifically for IAB is not part of the scope.  The study should coordinate with RAN4 as needed. |

# Summary of issues

## 2.1 General aspects of Network Energy Saving

* [2] Huawei, HiSilicon
  + Proposal 7: Send LS to RAN2/RAN3 to inform RAN1 identified techniques that may have higher layer impact.
* [8] CATT
  + Proposal 1: Time domain energy saving transition mechanism based on gNB state of system load should be supported for 5G network.
* [12] ZTE, Sanechips
  + For each potential network energy saving technique, their technique description, performance analysis including energy saving gain, impact on UPT and other KPIs, and specification impact should be captured into the TR.
* [16] LGE
  + Proposal #1: Consider to define NES state as operation mode of gNB applying one or more NES techniques, and to indicate whether or not NES state is applied or which NES state should be applied (if multiple NES states are configured).
* [23] Samsung
  + Proposal 1: Support at least the following three network states for the study of network energy saving:
    - Non-energy-saving state: the gNB/UE operates in a legacy way and no network energy saving technic is used;
    - Energy-saving state 1: UE does not transmit/receive any signal/channel;
    - Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel and/or applies bandwidth/PSD/TXRU adaptation for channel transmission/reception;
* [28] CEWiT
  + Observation 4: The adaptation of sleep states at gNB will have an impact on the legacy operations at UE.
  + Proposal 6: Signaling information about sleep state (E.g., type of sleep state, starting time and duration) to connected UE is supported.

### [CLOSED] 1st Round Discussions

There are several proposals that deal with general aspects of network energy saving being proposed by companies. For some proposals its not clear how the proposals will shape the TR and how they should be treated.

Interested companies are encouraged to provide text proposal that other companies can review for agreement/conclusion. Please provide suggestions below. Moderator will formulate the proposals for review based on comments received.

#### Company Comments

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| Company | Comments |
| vivo | Before agreeing what potential techniques to capture, we suggest some guidelines on which techniques can be captured/recommended in TR should be agreed first before writing the TR. For example, potential enhancement techniques should be clearly described and performance benefits should be justified by evaluation results, and the techniques without evaluation should not be captured/recommended in TR. |
| LG Electronics | As suggested in our Tdoc, we think defining NES state/mode can facilitate our further discussion on energy saving techniques, so the following proposal can be considered.  Proposal:   * Define a terminology “NES state”, as follows:   + NES state refers to the state in which gNB applies one or more network energy saving techniques in time/frequency/spatial/power domain. * UE can be provided with whether gNB is in NES state or not, or which NES state (if multiple NES states are configured) is applied by the gNB. |
| Huawei, HiSilicon | We suggest the following two principles from rapporteur’s point of view:   * + - 1. The techniques description should mostly only contain the new aspect compared to existing specification, thus those can be supported by implementation today, can be removed. The subjective texts (e.g., a scheme potentially results in higher gain) are not needed at this moment and are to be only considered after evaluations. Redundant description can be removed.       2. The techniques must be clear enough for others to simulate and compare, cannot be vague otherwise preferable to be clarified by proponent. (See side comments)   Also, the technique aspect can include generally 3 parts: techniques description (with potential need of UE assistance), perform analysis (to be complete after evaluations, potentially including impact on UE side), specification impact (may also include need of UE assistance information that may have RAN2 impact, and can be updated/iterated in next meetings) – in addition to the “impacts on network interfaces” that is agreed from RAN3 last RAN3 meeting, when applicable. Therefore, in this meeting, we would like to also identify potential RAN2 and RAN3 specification impact.  Furthermore, for this meeting, we can focus on what can be stabilized for being captured into TR, e.g. the description of techniques and potential higher layer specification impact. In the next meeting, it is expected that recommendation of a technique should be based on at least energy saving gain and potential specification impact among other factors, such as impact to UE. |
| Intel | Some suggestions regarding capturing descriptions into TR:   * A technique without potential specification impact is not considered for capturing into the TR   + Technique aspect can include generally 4 parts: techniques description, performance analysis (to be complete after evaluations, potentially including impact on UE side), need of UE assistance information, specification impact (can be updated/iterated in next meetings) – in addition to the “impacts on network interfaces” that is agreed from RAN3 last RAN3 meeting, when applicable.     - Impact may include quantitative and/or qualitative analysis. * It is expected that recommendation of a technique should be based on at least energy saving gain and potential specification impact among other factors, such as impact to UE. |
| CATT | The state of the system load, such as zero, low, light, medium and high system loads, and the transition from one state of system load to the other system load in achieving NES should be part of discussion. In particular, the NES gain performance of the proposed NES Cell ON/OFF techniques has strong implication triggering mechanism of one OFF cell to transition to ON state in achieving the network energy saving. The state of the system load and the state transition should be clearly described for any network energy saving techniques. |
| Ericsson1 | In our view, apart from energy savings gain, potential specification impact, factors including impact on other working groups should be considered. |
| Lenovo (from email) | As per chairman’s guidance, we think one area that RAN1 has to discuss to provide guidance to other WGs is whether to define  a gNB energy saving state (e.g. idle or inactive) without DL/UL data transmission/reception.  While RAN1 evaluates potential benefit of this gNB energy saving state, other WGs, e.g. RAN2 can study procedures to switch between a normal gNB state and the gNB energy saving state and RAN3 can study coordination of neighboring gNBs regarding energy saving state transition.  We suggest collecting and further discussing RAN1’s views on the gNB energy saving state in the next round of email discussions |

### Summary of 1st Round Discussions

Based on comments, moderator has put together Proposal #1-1 from LGE’s comments, and Proposal #1-2 based on Huawei, Intel, and Ericsson comments. Let’s discussion further on the proposal.

Proposal #1-1

* Define a terminology “NES state”, as follows:
  + NES state refers to the state in which gNB applies one or more network energy saving techniques in time/frequency/spatial/power domain.
* UE can be provided with whether gNB is in NES state or not, or which NES state (if multiple NES states are configured) is applied by the gNB.

#### Proposal #1-2

* A technique without potential specification impact is not considered for capturing into the TR
  + Technique aspect can include generally 4 parts: techniques description, performance analysis (to be complete after evaluations, potentially including impact on UE side), need of UE assistance information, specification impact (can be updated/iterated in next meetings) – in addition to the “impacts on network interfaces” that is agreed from RAN3 last RAN3 meeting, when applicable.
    - Impact may include quantitative and/or qualitative analysis.
  + The techniques description should mostly only contain the new aspect compared to existing specification, thus those can be supported by implementation today, can be removed. The subjective texts (e.g., a scheme potentially results in higher gain) are not needed at this moment and are to be only considered after evaluations. Redundant description can be removed.
  + The techniques must be clear enough for others to simulate and compare, cannot be vague otherwise preferable to be clarified by proponent.
* Apart from energy savings gain, potential specification impact, factors including impact on other working groups should be considered.
  + It is expected that recommendation of a technique should be based on at least energy saving gain and potential specification impact among other factors, such as impact to UE.

### Summary of GTW Session on Oct 12

From the GTW session discussion, Chairman suggested not spending too much time trying to agree on framework in which information are to be captured into the TR even though the spirit of the Proposal #1-2 is well understood and generally acceptable. Therefore, suggest to skip discussion on Proposal #1-2.

### [CLOSED] 2nd Round Discussions

Moderator asks companies to provide comments on Proposal #1-1.

#### Proposal #1-1

* Define a terminology “NES state”, as follows:
  + NES state refers to the state in which gNB applies one or more network energy saving techniques in time/frequency/spatial/power domain.
* UE can be provided with whether gNB is in NES state or not, or which NES state (if multiple NES states are configured) is applied by the gNB.

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| Company | Comments |
| Spreadtrum | Not necessary. It is not helpful for discussion or evaluation. We have 3 sleep states and 2 active states, we also have 2 categories… |
| CATT | We are OK with the definition of NES state. However, the NES state could also be transparent to the Rel-18 UEs and legacy UE. Thus, we don’t see the 2nd bullet is needed. |
| Futurewei | If the definition is to facilitate discussions on the differentiation of the various schemes, then it should be clarified that such is the motivation of the definition. We are open to this upon further clarifications. |
| QCOM2 | It is understood that having a structure is always helpful. Practically though, the generic NES state does not provide anything. Is it possible to elaborate a little bit more on this structure? |
| Ericsson2 | Not needed. It can be left to proponents to describe their technique in sufficient detail. |
| Lenovo | Given that RAN1 is discussing many candidate schemes and network should be able to choose one or multiple network energy saving techniques flexibly, trying to define multiple NES states based on combinations of various network energy saving techniques would be difficult and inefficient.  Instead, we think it is useful to define very basic states,   1. gNB being in a sleep state, where no transmission and reception occur, and/or   gNB being in a dormant state, where only min. common signal/channels are transmitted and/or min UL signal/channels are received. |
| Intel | We think it is useful for capturing description of different techniques in a unified manner. To this end, a general definition/terminology can be used to describe a network state such as NES state where energy saving is achieved by adaptation of resources. At least this can be used in TR. In order to distinguish from sleep states, it is clarified in second bullet that NES state implies BS transitioning to a state or mode of operation which requires notification to the UE. |
| Samsung | We support the proposal.  We think this feature is beneficial and has impact on other WGs.  RAN3 has made the following agreement and is waiting for RAN1’s decision.   |  | | --- | | **Cell DTX/DRX**           **The inter-node exchange of the cell DTX/DRX (if defined by RAN1/RAN2) is considered necessary.**  **Cell NES states**           **WA: The inter-node exchange on the NES states or more granular cells status information if defined by RAN1/RAN2 is needed if the benefits are confirmed. The detailed NES state or more granular information is pending to other groups.**  **Enhanced cell on/off**           **RAN3 considers that inter-node beam activation is needed, i.e. to request a neighbouring NG-RAN node to switch on beam(s) which has been deactivated.** | |
| OPPO | We are fine with the terminology “NES state” at least for discussion purpose. |
| CEWiT | We are fine with the proposal |
| Huawei, HiSilicon | Seems not necessary. We have already agreed the energy model for gNB, and there is no need to introduce this NES state in the description of techniques. |
| Fujitsu | We are OK to define NES state to facilitate the discussion. The second bullet is not needed since it is already covered by the proposals regarding specific techniques in time/frequency/spatial/power domain. For example, DL indication to adapt common channels and signals is equivalent to inform UE that gNB is in a NES state. |
| ZTE, Sanechips | We agree with other companies that we are discussing power saving techniques in multiple domains. Defining a general NES state is unclear about what refers to. It will also be confusing for other neighbouring cell about the exact NES techniques the resource cell is applied, if such an information is exchanged. |
| MediaTek | We do not support defining NES state.  Given UE has no knowledge of the ‘NES state’, we do not see the benefit of defining the ‘NES state’ since the specification is to specify UE behaviors.  Regarding the consideration of cross-BS information exchange, we would like to thank Samsung for sharing RAN3 information. But from the decision, ‘NES state’ is not the only option, as quoted below. Before we have clear idea about how many granularity or feasibility is useful for network energy saving, we think it is too early to define a NES state.   |  | | --- | | **… NES states or *more granular cells status information* …** | |
| InterDigital | We are fine with proposal #1-1 |

### Summary of 2nd Round Discussions

Companies in favor of defining NES state:

* CATT, Lenovo, Intel, Samsung, OPPO, CEWiT, Fujitsu, Interdigital
* Reasons: for describing the various techniques that relay upon specific power states of the gNB

Companies not in favor of defining NES state:

* Spreadtrum, Huawei, HiSilicon, ZTE, Sanechips, Mediatek
* Reasons: not necessary for discussion nor evaluation. For evaluation power model states are already defined.

Companies commented open to defining NES state but further discussion is needed on need:

* Qualcomm, Futurewei

There seems to be difference in opinion on the need for NES state definition. Moderator suggest to discuss the following.

#### Proposal #1-1A

* Define a terminology “NES state” to aid description of the potential energy saving techniques, as follows:
  + NES state refers to the state in which gNB applies one or more network energy saving techniques in time/frequency/spatial/power domain.
* ~~UE can be provided with whether gNB is in NES state or not, or which NES state (if multiple NES states are configured) is applied by the gNB.~~

### Conclusion from GTW session on 10/16

From the discussions, it was quite clear, companies are split in opinions on whether defining “NES state” even for aiding description of the NW energy saving techniques is needed. Chairman suggested not spent further time on this, and try to work on the description without the definition.

Based on this moderator assumes this discussion is closed for this meeting.

### == Discussion Closed ==

## 2.1A Energy Saving Techniques

This is newly created section to handle the disclaimer text that is suggested to be part of the agreement for description of the potential energy saving techniques.

### [ACTIVE] Discussions

Moderator suggest to agree on this text as boilerplate for any agreed proposals on potential technique description.

Proposal #1-2

The following are description of a potential energy saving techniques being discussed in RAN1. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

#### Company Comments on Proposal #1-2

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| --- | --- |
| Company | Comments |
| - | - |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
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### Summary of Discussions

Moderator suggest to discuss the boilerplate language that will be used to capture the agreements on the techniques in RAN1.

#### Proposal #1-2 – GTW Check Needed

The following are description of a potential energy saving techniques being discussed in RAN1. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

## 2.2 Time-domain based Energy saving Techniques

* [1] Futurewei
  + Observation 1: Support of selective transmission/reception of SSB and SIB1 should be enhanced with group-common or cell-common signaling to the UE(s) on the changes in the SSB/SIBs transmissions.
  + Observation 2: Group-common or cell-common signaling of CSI-RS would provide an efficient signaling that supports bandwidth adaptation for network energy savings.
  + Proposal 1: UE grouping and group common signaling to support efficient network resource adaptation should be introduced and supported.
  + Observation 3: Resource adaptation at the multicell-level can provide an effective adaptation towards network energy savings.
  + Proposal 2: Multicell-level resource adaptation, cell-level resource adaptation, and sub-cell-level resource adaptation should be introduced and supported.
  + Observation 4: The UE should support being configured through RRC signaling the different conditions/triggers for the UE to send an UL Wake-Up signal.
  + Proposal 3: Assistance information in the form of an UL wake-up signal from the UE to the gNB should be introduced and supported. Support of an UL wake-up signal that can be specific to different use cases should be studied.
* [2] Huawei, HiSilicon
  + Observation 1: There can be up to 30% symbols for FR1 and 15% symbols for FR2 being active in time for the network to only transmit SSB and SIB1.
  + Proposal 1: The potential techniques of reduction of common signals and channels, particularly SSB and SIB1 and PRACH, should be studied in first priority and should be captured in TR.
  + Observation 2: For a UE operating with single carrier, synchronization with gNB needs to be achieved before the transmission of uplink trigger signal in the technique of on-demand SSB.
  + Observation 3: For a UE operating with single carrier, light/simplified version of SSB, e.g. DRS, can be used as the essential synchronization signal before the transmission of uplink trigger signal for on-demand SSB technique.
  + Proposal 2: Evaluate on-demand SSB/SIB1 transmission with light/simplified common signal with the following assumptions:
    - Two symbol DRS with the broadcast periodicity of 20ms for synchronization before the transmission of uplink triggering signal;
    - The interval between two neighboring WUS occasions can be 20ms, with certain detection probability, e.g. 1%, depending on different UE density and HO probability;
    - Upon receiving WUS, gNB starts to broadcast SSBs and SIB1 periodically from the next SSB-burst, for e.g. 1 or twice for certain reliability.
  + Proposal 3: Further study possible methods to adapt the time domain transmission of common signals, e.g. SSB and SIB1 for NR in consideration of common signals in neighboring LTE carrier that is deployed on the same base station. Note that only changes in NR are expected as per SID.
  + Observation 4: Due to the signaling overhead of reconfiguration/deactivation of UE specific channels and signals, cell-specific or UE group common dynamic signaling for adaptation on UE specific signals and channels is an optimization to further decrease the energy consumption of gNB.
  + Observation 5: The C-DRX adaptation on UE and gNB DTX/DRX (re)configuration should be jointly discussed with the reconfiguration of the UE specific periodic or Semi-Persistent signals considering the current UE C-DRX mechanism does not apply on periodic or Semi-Persistent signals/channels.
* [3] Nokia, Nokia Shanghai Bell
  + Proposal-1: For time-domain NW ES adaptations, enhancements for increasing BS (µ)DTX opportunities can be prioritized.
  + Proposal-2: Study enhancements for extending network sleeping modes opportunities including (µ)DTX indication to UE e.g. for UE power saving.
  + Proposal-3: Enhancements leveraging UE assistance / indication for (de)activation of unnecessarily CG-PUSCH resources can be studied to increase (µ)DRX / network sleeping opportunities.
  + Proposal-4: As part of study of time-domain NW ES techniques, further adaptation / reduction of SSB/SIB1 transmissions can be prioritized.
  + Observation-1: The existing paging design distributes the paging occasions evenly in time, which minimizes the possibility for a base station to sleep between paging occasions.
  + Proposal-5: Study possibilities to save base station energy via time domain enhancements of the paging mechanism.
  + Proposal-6: Study enhancements enabling faster cell deactivation / reactivation and faster offloading of UEs to neighboring cells.
* [4] Spreadtrum Communications
  + Observation 1: The reduction of common signal/channel can provide the energy saving gain, but it needs be realized by other techniques, e.g. dynamic cell on/off and DTX.
  + Proposal 1: Study in which scenarios the reduction of common signal/channel can be reduced without affecting UEs mobility and initial access.
  + Observation 2: Dynamic cell on/off with load balance can provide the energy saving gain.
  + Observation 3: DTX with traffic concentration can provide the energy saving gain, if the energy consumption of empty load is higher than that of a give sleep mode plus transition energy.
* [5] vivo
  + Proposal 1: Support adaptation of common signals and channels and capture the following in TR:
    - Technique description: Dynamic/Flexible adaptation of Dl and/or UL common signals and channels triggered by gNB (e.g., from normal period to long period when gNB becomes inactive state) or UE WUS (e.g., from long period to normal period when needed);
    - Performance analysis: This technique is beneficial for network energy saving especially when gNB is in inactive state;
    - Spec impact: It is needed to specify how to signal the adaptation and related UE behaviour based on the signalling, how to make the adaptation (e.g., period), WUS channel and procedure design to trigger the adaptation.
  + Proposal 2: The benefit and motivation of dynamic adaptation of UE specific signals and channels compared to implementation-based schemes needs to be clarified and evaluated.
  + Observation 1: Wake up of energy saving gNB by neighbour cell gNB can be supported by current implementation.
  + Observation 3: In non-HetNet case, legacy load-based energy saving cell activation can’t be used since neighbor cell gNB has no knowledge on how many UEs (especially idle/inactive UEs) moves to the energy saving cell’s coverage area.
  + Observation 4: The UE WUS scheme can achieve a good BS power gain without a significant reduction in UPT, especially low loads.
  + Proposal 3: Support wake up of gNB by UE WUS and capture the following in TR:
    - Technique description: Wake up of gNB that is in an energy saving state (e.g. no or sparse transmission or reception of common signals and channels) triggered by WUS from idle/inactive/connected state UEs;
    - Performance analysis: This technique is beneficial for network energy saving without significant loss of UE performance;
    - Spec impact: It is needed to specify WUS signal design, WUS configuration design and WUS procedure design.
  + Proposal 4: The benefit and motivation of adaptation of DTX/DRX compared to implementation-based schemes needs to be clarified and evaluated.
  + Proposal 5: The benefit and motivation of adaptation of BS inactive state compared to implementation-based schemes needs to be clarified and evaluated.
* [6] China Telecom
  + Proposal 1: Longer periodicity of SSB/SIB(e.g. 320ms) should be supported for BS energy saving.
  + Observation 1: If the WUS for gNB is supported, the on-demand SSB can be supported with less additional impact at the same time.
  + Proposal 2: On demand SSB should be supported for BS energy saving, especially if WUS for gNB is supported.
  + Proposal 3: The self-adapted configuration of SSB periodicity should be supported for BS energy saving.
  + Proposal 4: The 2-step semi-persistent symbol switch on-off should be supported in Rel-18.
* [7] OPPO
  + Proposal 1: Consider the following text proposal for TR 38.864.
    - Support of association between SSB for a sleeping cell and CORESET#0 for an active cell can be considered, such that SIB1 can be provided in the active cell for the sleeping cell to achieve a tradeoff between access latency and energy saving gain.
  + Proposal 2: Consider the following text proposal for TR 38.864.
    - Support of UE reporting activation/deactivation information for UE specific signals and channels is beneficial to reducing the number of time occasions at gNB side during periods of low activity and can be considered.
  + Proposal 3: Consider the following text proposal for TR 38.864.
    - Support of wake up signal (WUS) for gNB configuration for a UE in connected mode is recommended for a gNB operating in a sleeping mode, where the connected mode UE can transmit a scheduling request via this WUS to gNB to reduce the scheduling latency and UPT degradation.
  + Proposal 4: Consider the following text proposal for TR 38.864.
    - Support of DTX/DRX cycle for gNB is recommended to achieve energy saving gain, where the UE shall not assume SSB or CSI-RS is transmitted during an off period in a DTX/DRX cycle for gNB. Support of association between gNB-WUS or UE-WUS and DTX/DRX cycle for gNB is beneficial to wake up the gNB or the UE and can be considered.
* [8] CATT
  + Observation 1: To achieve obvious network energy saving gain, transmission periodicity of common channels/signals should be long enough to allow gNB to stay in deep sleep state.
  + Proposal 2: With the increase of the transmission periodicity of common control channels/signals in a cell, the impacts on initial access procedure for legacy RRC Idle/Inactive mode UE should be considered and network energy saving gain should be further evaluated in case of providing service to RRC connected mode UEs.
  + Proposal 3: How to prevent the legacy Idle/Inactive mode UE from residing in cells with increased the SSB periodicity by reducing the cell access priority should be considered.
  + Observation 2: For zero system load, with increase of common control channel periodicity, it could obtain network energy saving gain from 18.8% to 82.6% based on different common control channel periodicity.
  + Observation 3: For zero system load, major network energy saving gain could be achieved within the common control channel periodicity of 160ms.
  + Observation 4: From non-zero system load cell perspective, gNB could not enter deep sleep state and limited energy saving gain can be achieved for non-zero system load.
  + Proposal 4: Up to 160ms transmission periodicity of SSB/SIB is preferred for the network energy saving.
  + Proposal 5: Long SSB periodicity containing several short periodic SSB could be configured to achieve trade-off of network energy saving and UE power saving /paging latency.
  + Proposal 6: For Rel-18, semi-static/dynamic cell ON/OFF should be supported for network energy saving.
  + Observation 5: The slot/symbol granularity is not feasible for long transition time of Cell ON/OFF.
  + Proposal 7: Network control mechanism in triggering the transmission of on-demand DRX from the turned-OFF cell (e.g., on-demand SSB) should be considered for the network energy saving.
  + Proposal 8: For semi-static/dynamic cell ON/OFF, on-demand DRS should be studied for network energy saving.
  + Observation 6: It could be observed 23.8% and 47.3% network energy saving gain for semi-static/dynamic cell ON/OFF scheme and with additional gNB DTX scheme during Cell ON respectively.
  + Observation 7: Without achieving DL synchronization, the energy saving cell could not be directly woken up by the UE via the gNB WUS signal.
  + Observation 8: When system load is low and the less number of UEs access the system, the staggering C-DRX configuration for system load balancing becomes unnecessary.
  + Observation 9: gNB could reduce the energy consumption with the DTX transmission in low system load state by allocating same set of C-DRX configuration for all UEs, which including DTX-ON and DTX-OFF.
  + Proposal 9: The gNB DTX/DRX should be considered to reduce network energy consumption for low system load state.
  + Proposal 10: DTX parameters should be configured to Rel-18 UEs through high layers and gNB DTX-ON duration should be associated with Active Time of UEs and cover the reception window of DCI format 2\_6.
  + Proposal 11: DTX/DRX coordination in Uu, Xn and NG should be supported for reduction of network energy consumption.
  + Observation 10: gNB DTX transmission with centralized DRX-ON configuration can obtain 50.1%~75.3% energy saving gain. High Network Energy Saving gain is observed at the low system load.
* [9] Fujitsu
  + Observation 1. When a cell is turned off with short duration (e.g., symbol/slot/subframe-level), keeping UEs connected with the cell can avoid ping-pong handover and frequent activation/deactivation.
  + Proposal 1: During no-load period, base station can turn off the cell to save energy consumption and the following techniques can be considered to extend the cell off duration
    - Enlarging common signal periodicity
      * The impact on initial access procedures for legacy UEs should be avoided
      * FFS: How to avoid impact on initial access procedure for legacy UEs
    - Reducing transmission occasions of UE-specific periodic CSI RS
      * The impact to RLM and RRM measurement operation based on periodic CSI-RS should be addressed
      * FFS: Enhancements on CSI-RS based RLM and RRM measurement operation
  + Proposal 2. Study the following methods to aid discovery of SSB-less cells,
    - via DRS on SSB-less cells
    - via reference signal of another cell (e.g., an anchor cell)
  + Proposal 3. Adopt BWP adaptation as a fast energy saving state switching approach.
    - BWP adaptation can be utilized with frequency/time/spatial/power-domain energy saving techniques.
    - FFS: Enhancement of the existing BWP switching mechanism.
* [10] Intel
  + Observation 1: BS power model category 2 requires cell to have much longer periods of non-activity, e.g. in the order to 640 msec to 10 sec, before deeper sleep modes can be leveraged. Since the user traffic are generated on average of 200 msec, cells that have any active user may not be able to leverage deeper sleep modes. This creates difficulty in obtaining insightful observations even at low load scenarios.
  + Observation 2: More than 30% power saving gains are observed when network is under low loads (below 15% resource utilization) and network increases the common signal transmission periodicity from 20 msec to 160 msec or longer.
  + Proposal 1: RAN1 should investigate further into techniques that allow reduction of common signals (i.e. increasing periodicity) such as SSB, SIB1, and PRACH for low and lightly load scenarios.
  + Observation 3: Up to 25% power saving gains are observed from paging enhancement that compact the POs to be more bursty (e.g. consecutive slots and/or frames) when network is with zero data load (o% resource utilization) but with low paging loads.
  + Proposal 2: RAN1 should investigate further into techniques that allow compacting paging resources into consecutive slots/frames for zero data load scenarios.
* [11] Lenovo
  + Observation 1: SSB periodicity configuration per SSB subset can reduce SSB transmission time substantially (e.g. 20~50% reduction). When a cell is in a cell inactive state only transmitting SSBs and minimum system information, SSB transmission with subset-specific SSB periodicity can achieve 20~50% network energy saving gains.
  + Observation 2: Even though there is a mismatch between an actual SSB transmission periodicity and legacy UE’s assumption, legacy UEs would not select a SSB not being transmitted based on measurement. Thus, impact on the legacy UEs is expected to be minimal.
  + Proposal 1: Support SSB transmission with multiple SSB periodicities for multiple SSB subsets, each SSB periodicity applicable to each SSB subset.
  + Observation 3: Dynamic indication of transmitted SSBs in a SSB burst allows dynamic omission of SSBs and corresponding paging PDCCH/PDSCH and SI PDCCH/PDSCH for a certain duration.
  + Proposal 2: Support dynamic indication of transmitted SSBs in a SSB burst to enable gNB to dynamically omit and add back SSBs that are semi-statically indicated as being transmitted, as frequently as in every 160ms, for network power savings.
  + Proposal 3: Include the following texts in TR38.864:
    - Technique #A-1 Adaptation of common signals and channels
      * When a cell is in a cell inactive state, where the cell transmits only SSBs and minimum system information (e.g. simplified SIB1), the cell can be configured with multiple SSB subsets and corresponding multiple SSB periodicities, i.e. each SSB subset (i.e. SSBs with a subset of SSB indices) associated with one SSB periodicity.
      * When a cell is in a cell active state, where the cell transmits SSBs, system information, paging, TRS/CSI-RS, and user data, the cell can dynamically omit and add back SSBs that are semi-statically indicated as being transmitted, as frequently as in every 160ms.
    - Analysis for technique #A-1
      * When a cell is in a cell inactive state only transmitting SSBs and minimum system information, SSB transmission with subset-specific SSB periodicity can achieve 20~50% network energy saving gains.
      * When multiple SSB-subset specific periodicities are configured in a cell, legacy UEs assuming one SSB periodicity would not select a SSB not being transmitted based on measurement. Thus, impact on the legacy UEs is expected to be minimal.
      * When SSBs are dynamically omitted and added back as frequently as in every 160ms, corresponding paging PDCCH/PDSCH and SI PDCCH/PDSCH can also be dynamically omitted and added back accordingly.
  + Spec impact for technique #A-1
    - Configuration of SSB subsets and corresponding subset-specific SSB periodicities
    - Dynamic indication of time domain positions of transmitted SSBs in a SSB burst
* [12] ZTE, Sanechips
  + The SSB-less and SIB-less scheme can obtain 6.5% ~ 24.2% energy saving gain for TDD and 14.9%~45.5% energy saving gain for FDD in the cases RU=5%~40%. The SSB-less and SIB-less scheme can obtain about 2.1%~11.7% UPT benefits in the cases RU=5%~40%.
  + A serving cell with DL common signal/channel (i.e., SSB, SIB) reduction can be considered for network energy saving.
  + UEs can obtain SIB from an assistant cell.
  + The impact of common signal reduction (e.g. SSB, SIB reduction) on uplink transmission (e.g. PRACH) should be considered.
  + An uplink WUS sent by UE can be considered for DL common signal/channel (e.g., SIB/SSB) adaption or cell activation operation.
  + Capture the following description in the network energy saving techniques in time domain in the TR.
    - Adaptation of common signals and channels.
    - Performance analysis
      * The SSB-less and SIB-less scheme can obtain 5%~14.8% energy saving gain in the cases of RU=5%~25% for TDD and 9.4%~26.4% energy saving gain in the case of RU=5%~15% for FDD.
    - Specification impact may include
      * UEs obtain SIB from an assistant cell.
      * The impact of common signal reduction (e.g. SSB, SIB) on uplink transmission (e.g. PRACH).
      * An uplink WUS sent by UE for DL common signal/channel (e.g., SIB/SSB) adaption or cell activation operation.
* [13] Xiaomi
  + Proposal 1: For dynamic cell on-off, how to reduce the interruption duration for RRC-idle UE and avoid unnecessary handover or simplify the handover procedure for RRC-connected UE should be studied.
  + Proposal 5: Enhancement for NCD-SSB to reduce or avoid PBCH transmission can be studied.
  + Observation 1：Type #0 CSS transmission does not need to be as frequent as SSB.
  + Proposal 6: Reduced Type #0 CSS transmission can be studied.
  + Proposal 7: Reduced transmission for UE request SI can be studied.
* [14] CMCC
  + Observation 1: gNB has to make sure SSB and SIB1 are transmitted at least every 20ms for idle UEs to access the cell, enhancements can be made to reduce SSB/SIB transmission.
  + Observation 2: Reducing SSB/SIB1 transmission for single carrier case will have impact on legacy UEs’ initial access performance, so it should be careful to apply such schemes to network with legacy UEs.
  + Observation 3: Reducing SSB/SIB1 transmission for single carrier case can be considered for new deployment with only new UEs.
  + Proposal 7: The following alternatives can be considered to reduce SSB/SIB transmission,
    - Alt1: Increasing repetition period of SIB1
    - Alt2: Increasing repetition period of PBCH and SIB1
    - Alt3: Increasing repetition period SSB and SIB1
  + Proposal 8: SSB/SIB1 less carrier can be considered for single carrier option with assistance information from other carriers.
  + Proposal 9: When reduced SSB/SIB1 transmission is introduced, the potential specification impacts include:
    - Adapting the repetition periods of common channels/signals
    - On-demand triggering of common channels/signals, including the triggering signaling design, and the triggering procedure.
  + Proposal 10: When SSB/SIB1 less carrier is introduced, the potential specification impacts include:
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
  + Proposal 11: The potential specification enhancement of reducing transmission of UE specific channels/signals includes: dynamic signaling design to reduce transmission of these UE specific channels/signals, by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
  + Proposal 12: The potential specification enhancements of DTX/DRX of gNB include:
    - Mechanisms to align C-DRX configuration of UE, such as signaling design to align the C-DRX configuration.
    - Defining DTX/DRX pattern for gNB.
    - Wake up signal (WUS) for gNB, including how to provide WUS configuration, such as by RRC release information or by neighboring gNB, and also the wake up related procedure.
  + Proposal 13: Technique aspects related to time domain are summarized as follows:
    - Technique #TD-1: Reducing transmission of common channels/signals
      * Techniques description: SSB and SIB1 are transmitted with a default period, such as 20ms, the power consumption of gNB can be reduced by increasing the periodicity of common channels/signals, such as SSB, SIB1 PDCCH/PDSCH or by introducing SSB/SIB1-less cell. The following alternatives can be considered to reduce SSB/SIB1 transmission,
      * TD1-1: Increasing the periodicity of common channels/signals can be realized by,
        + Alt1: Increasing repetition period of SIB1
        + Alt2: Increasing repetition period of PBCH and SIB1
        + Alt3: Increasing repetition period SSB and SIB1.
        + Specification impacts:

Adapting the repetition periods of common channels/signals

On-demand triggering of common channels/signals, including the triggering signaling design, and the triggering procedure.

* + - * TD1-2: SSB/SIB1 less carrier for single carrier operation, with assistance information from other carriers
        + Specification impact:

Cross carrier synchronization for single carrier operation

System information enhancement to provide other carriers’ information and carrier selection principles for UE

* + - Technique #TD-2: Reducing transmission of common channels/signals
      * Techniques description: reducing the number of time occasions for the following resources during periods of low activity may potentially provide energy saving benefits.
      * CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
      * Specification impact:
        + Dynamic signaling design to reduce transmission of these UE specific channels/signals, by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
    - Technique #TD-3:DTX/DRX of gNB
      * Techniques description: DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, then the power consumption can be reduced.
      * Specification impact:
        + Mechanisms to align C-DRX configuration of UE, such as signaling design to align the C-DRX configuration.
        + Defining DTX/DRX pattern for gNB.
        + Wake up signal (WUS) for gNB, including how to provide WUS configuration, such as by RRC release information or by neighboring gNB, and also the wake up related procedure.
* [15] NEC
  + Proposal 1: gNB DTX and DRX should be supported, and the impact on UE operation, e.g., the measurement, synchronization and C-DRX procedures, should be considered.
  + Proposal 2: Support configurable periodicity and offset for fully flexible time domain energy saving pattern, and simultaneous multiple configurations should be considered.
  + Proposal 3: Support SS/PBCH transmission with reduced density, on-demand SSB and dynamically adjustable SSB transmission periodicity.
* [16] LGE
  + Proposal #5: It is beneficial to switch off gNB’s periodic/semi-persistent transmission (and/or reception) at least when gNB does not need to transmit data to the UE, in terms of network energy savings.
  + Proposal #6: Study how to support efficient mechanisms to switch off gNB’s transmission (and/or reception) for a specific period of time.
  + Proposal #7: Whether or not to support adjustment of SSB transmission and on-demand procedure for common channels/signals such as SIB1, paging, or PRACH, should be carefully studied at least considering impacts on initial access procedure and measurements, and how to enable on-demand procedure.
  + Proposal #8: Study how to support a mechanism for waking gNB up from NES state when new data arrives at UE.
  + Proposal #9: Consider to support UE’s report of zero buffer status by transmitting PUCCH with negative SR.
  + Proposal #10: Study at least the followings to enhance UE’s DRX mechanism for the purpose of network energy saving.
    - Group common indication for DRX commend, such as DRX command MAC CE and long DRX command MAC CE
    - DRX active time alignment from the gNB’s perspective, by adjusting the starting position of DRX on-Duration via group-common indication or by switching between UE-specific and group-common DRX configurations
    - DRX on/off control for multiple DRX cycles, by informing DRX-off for N DRX cycles with a single indication
    - Minimization of gNB’s activity outside DRX active time, by invalidating CSI-RS reception or UL signal/channel transmission outside DRX active time
* [17] Mediatek
  + Observation 1: For the case of low network load (0% - 15%) while there are still (frequent) user activities (e.g., VoIP), aligning UE DRX offset for aggregated BS activity can achieve good power saving gain, i.e., >28% for Cat 1 BS and >10% for Cat 2 BS.
  + Proposal 1: Aligning UE DRX offsets in a group-specific or cell-specific manner is recommended for network energy saving.
  + Observation 2: Monitoring PRACH preamble for a sleeping cell, e.g., a deactivated small cell, is beneficial for NW to determine whether to turn on/off a BS.
  + Proposal 2: For dynamic BS on/off, enhancement on PDCCH-order-based RA can be used as a BS wake-up request.
  + Observation 3: BS may not trigger cell reselection for an IDLE UE camping on a cell before BS turns off the cell (without cellBarred) because cell reselection is based on RSRP and RSRQ measurement.
  + Proposal 3: For dynamic BS on/off, enhancement on cell reselection for IDLE UE should be investigated to minimize the impact to IDLE UEs.
* [18] Apple
* Technique #A-1 Adaptation of common signals and channels
  + Network energy saving can be realized by flexibly varying the periodicity and/or dynamically changing a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or flexibly varying the periodicity of uplink random access opportunities.
    - This also include introducing light version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.
    - This is mainly for BS idle/inactive mode, e.g. cell deactivation without DL data transmission.
    - [Comment] this does not seem to be a complete solution, because mechanisms are necessary to put the BS back to normal operation. It should be clarified what other techniques are needed to make this complete.
  + Support of burst transmission and reception of common signals and channels with more than one periodicity and/or adaptation of a burst pattern, including periodicity, are expected to potentially provide longer inactivity periods for the gNB and potentially provide higher power saving gains.
    - [Comment] Is this only applicable to green field deployment? Does this prohibit legacy UEs from accessing this BS?
  + Support of dynamic adaptation of SSB/SIB transmission or on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB and potentially provide energy savings.
    - [This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA. and/or support offloading system information from one cell to another for inter-band CA.]
    - This may include support of signals/channels to aid discovery of cells in lieu of SSBs.
    - This may include support of mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.
    - It should be noted that use of CA means the technique is only applicable to UEs in connected mode.
    - [Comment] If the intention is to use it in the context of CA, should this be merged together with technique B-1? Otherwise, sufficient distinction is needed between the two.
  + [Support of scheduling enhancements for SIB1 along with a long period (rather than the period as the same as the SSB period) adaptation of CORESET 0 (e.g. in a separately configured CORESET) are expected to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB and potentially provide higher power saving gains.]
    - This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0
    - This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead
    - [Comment] It is not clear how much benefit can be achieved by omitting PDCCH if SSB still needs to be transmitted. May be deprioritized in our view.
    - ~~Dynamic a~~Adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.
    - [Comment] the exact impact should be further clarified for each of the sub-bullets above. For example, would it prohibit legacy UE from accessing the cell or just introduce longer latency for legacy UE to access the cell?
* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Network energy saving opportunities may be restricted by UE specific signals and channels that are semi-statically configured such as periodic or semi-persistent CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Reducing the number of time occasions for or temporarily disabling the following resources during periods of low activity may potentially provide energy saving benefits.
    - CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
    - This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.
  + Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.
    - Support of configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
    - Support of group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals
  + The impact to the UE performance by adaptation of UE specific signal/channels should be included along with the network energy saving performance results.
* Technique #A-3: wake up signal (WUS) for gNB
  + Support of wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), support of wake up signal (WUS) transmitted by the UE/neighboring gNB including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).
    - Whether UE detection of a dormant power state/energy saving state is required before WUS transmission should be identified.
    - Resource reserved for WUS and the assumption of the gNB receiver should be identified
    - This may include support of assistance information from the UEs intended to aid wake up operations by the gNBs.
  + This is mainly for connected mode UEs
  + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.
    - The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.
    - A legacy UE cannot access a gNB in such dormant power state/energy saving state.
* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle mode can potentially provide longer inactivity periods at the gNB.
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS.
    - [Comment] this sentence seems unclear.
    - The ~~two~~ techniques/approaches of DTX/DRX alignment can be complementary to each other and they may be beneficial to energy savings both at the network and at the UE side.
    - [Comment] It is not clear what are complementary to each other.
  + ~~[Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time may potentially provide energy saving benefits, such as SSB or SIB.]~~
  + Reduction of periodically transmitted/semi-static configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time).
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication can potentially provide longer inactivity periods at the gNB.
  + This may include group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced command MAC CE and long DRX commend MAC CE.
* Technique #A-5: Adaptation of BS inactive state or DTX/DRX
  + Support of gNB entering into sleep mode (or DTX/DRX state) for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration are expected to potentially provide flexible adaptation at the gNB and can potentially provide higher power saving gains.
    - This may include support of semi-static and/or dynamic gNB active/inactive state (or DTX/DRX state) adaptation.
    - This may include group common signaling for the indication of adapted active/inactive state (or DTX/DRX state)
    - This may include defining corresponding UE behaviors when gNB enters inactive state or sleep mode
* [19] Fraunhofer IIS, Fraunhofer HHI
  + Observation 1: When a gNB is not serving any user, it could be very useful to set larger intervals between SSBs so that the gNB can go into a deeper sleep mode thereby saving energy.
  + Observation 2: The trade-off between network energy saving (NES) gains and initial access performance applies not only to the extended periodicity approach of NES but also to the on-demand SSB transmission approach due to the need for prior DL synchronization.
  + Observation 3: Since legacy UEs performing initial access would expect SSB burst transmissions with 20 ms periodicity, either many cells would be constrained to setting the SSB periodicity to 20 ms or cells transmitting larger SSB periods than 20 ms may be missed by legacy UE performing initial cell search.
  + Proposal 1: The impact of larger SSB periodicities on the initial access of UEs must be studied in detail both from the perspective of legacy UEs and NES-aware UEs (Rel-18 and beyond).
  + Proposal 2: Investigate techniques which increase gNB inactivity as much as possible while attaining acceptable initial cell-search performance.
  + Proposal 3: Improve the UE initial access such that the initial access would not be impacted due to the NES techniques adapting SSB periodicity or via on-demand SSB transmission.
  + Proposal 4: Define a System Presence Indicator (SPI) that indicates to the UEs the presence of gNBs transmitting SSBs within a block of frequencies.
  + Proposal 5: Include the following bullets to the description of Technique #A-1: Adaptation of common signals and channels, in the TR:
    - As adaptations of common channel/signal providing longer inactivity at the gNB for cell deactivation without DL transmission, including dynamic adaptation of the periodicity of transmission (of e.g., of SSBs) and on-demand SSB transmission, might have impact to the UE normal access to the network, such as initial access, and legacy UE network access, techniques to reduce such impact are needed
      * This may include utilizing the introduction of simplified signals in lieu of SSBs or prior to SSBs to improve the initial access process such that the performance would not be affected due to the NES techniques adapting SSB periodicity or via on-demand SSB transmission
      * This may include defining a System Presence Indicator (SPI) that indicates to the UEs the presence of gNBs transmitting SSBs within a block of frequencies in order to improve initial access performance. These SSBs may use a larger periodicity or on-demand through UE trigger, in order to provide energy savings.
  + Observation 4: A System Presence Indicator (SPI) defined for the speed up of Initial Cell Search can serve as the downlink synchronization signal for uplink wake-up signal (UL-WUS).
  + Proposal 6: An uplink wake-up signal (UL-WUS) can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
  + Proposal 7: Include the following bullets to the description of Technique #A-3: Wake up signal (WUS) for gNB, in the TR:
    - An uplink wake-up signal (UL-WUS) can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - For DL synchronization needed for the UL WUS signal can be obtained via the System Presence Indicator (SPI) defined for the speed up of Initial Cell Search
* [20] Rakuten
  + Proposal 2: Sleep mode of the gNB should be indicated to the UE.
  + Proposal 4: Consider wake-up signal for gNB activation.
* [21] Panasonic
  + Proposal 1: Time domain adaptation should be considered with higher priority. The PDCCH monitoring controlled by DRX adaptation can be considered as starting point. It can be inclusive for other channel/signal related enhancement. When beam sweeping operation is utilized, beam on/off by adapting SSB/CSI-RS can also be considered as a time domain adaptation enhancement.
* [22] Interdigital
  + Proposal 1: Capture the following in TR38.864 (changes from R1-2208185 indicated in red):

|  |
| --- |
| Time Domain Techniques  * Technique #A-1 Adaptation of common signals and channels   + Network energy saving can be realized by flexibly varying the periodicity and/or dynamically changing a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or flexibly varying the periodicity of uplink random access opportunities.     - This also include introducing light version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.     - This is mainly for BS idle/inactive mode, e.g. cell deactivation without DL data transmission.   + Support of burst transmission and reception of common signals and channels with more than one periodicity and/or adaptation of a burst pattern, including periodicity, are expected to potentially provide longer inactivity periods for the gNB and potentially provide higher power saving gains.   + Support of [dynamic adaptation of SSB/SIB transmission or] on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB and potentially provide energy savings.     - [This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA. and/or support offloading system information from one cell to another for inter-band CA.]     - This may include support of signals/channels to aid discovery of cells in lieu of SSBs.     - This may include support of mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - It should be noted that use of CA means the technique is only applicable to UEs in connected mode.   + [Support of scheduling enhancements for SIB1 along with a long period (rather than the period as the same as the SSB period) adaptation of CORESET 0 (e.g. in a separately configured CORESET) are expected to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB and potentially provide higher power saving gains.]     - This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0     - This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead   + Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.   + Specification impacts may include support for UE determination of transmission pattern of the downlink common and broadcast signal, such as based on explicit indication or autonomous detection. Impact to legacy UEs include longer access delays or not being able to perform initial access in the cell when SSBs and SI are not broadcast as expected. * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Network energy saving opportunities may be restricted by UE specific signals and channels that are semi-statically configured such as periodic or semi-persistent CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).   + Reducing the number of time occasions for the following resources during periods of low activity may potentially provide energy saving benefits.     - CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).     - This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.   + Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.   + Support of configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE/cell group-level or ccell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.   + The impact to the UE performance by adaptation of UE specific signal/channels should be included along with the network energy saving performance results.   + Specification impacts may include configuration of resources available in each network energy saving state and dynamic indication of a network energy saving state. Legacy UEs are not able to use resources in all network energy saving states. * Technique #A-3: wake up signal (WUS) for gNB   + Support of wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), support of wake up signal (WUS) transmitted by the UE/neighboring gNB including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).     - Whether UE detection of a dormant power state/energy saving state is required before WUS transmission should be identified.     - Resource reserved for WUS and the assumption of the gNB receiver should be identified     - This may include support of assistance information from the UEs intended to aid wake up operations by the gNBs.   + This is mainly for connected mode UEs   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area. WUS design may be selected so as to ensure reasonable coverage while enabling low-complexity gNB reception, e.g. sequence-based design.   + Specification impacts may include design of WUS and conditions for triggering WUS transmission. * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle mode can potentially provide longer inactivity periods at the gNB.     - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.   + An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS.   + The ~~two~~ techniques/approaches of DTX/DRX alignment can be complementary to each other and they may be beneficial to energy savings both at the network and at the UE side.   + [Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time may potentially provide energy saving benefits, such as SSB or SIB.]   + Reduction of periodically transmitted/semi-static configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time).   + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication can potentially provide longer inactivity periods at the gNB.   + This may include group level indication for switching to a DRX cycle configured for network energy saving~~, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced command MAC CE and long DRX commend MAC CE~~.   + Specification impacts may include configuration of DRX cycle configured for network energy saving and indication of switching to this DRX cycle. * Technique #A-5: Adaptation of BS inactive state   + Support of gNB entering into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration are expected to potentially provide flexible adaptation at the gNB and can potentially provide higher power saving gains.     - This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.     - This may include group common signaling for the indication of adapted active/inactive state   + Specification impacts may include design of signaling indicating the network energy states in current or future time periods. Impact to legacy UEs can include longer access delays or not being able to access the cell in some BS inactive states. |

* [23] Samsung
  + Proposal 2: Support semi-static switching and dynamic switching for network states transition (cell ON/OFF) of a serving cell at least for single cell case.
    - For a TDD band, network states transition (cell ON/OFF) switching can apply jointly or separately to DL and UL.
  + Observation 1: Current NR system requires large signaling overhead to adapt time domain resources for p/sp physical layer resources via RRC reconfiguration or semi-static (de)activation per UE.
  + Proposal 3: Support cell-specific/UE group common dynamic adaptation on periodic/semi-persistent physical layer resources in DL or UL for NW energy savings.
  + Proposal 4: Support SSB periodicity larger than 160ms.
  + Proposal 5: Support SSB transmission reduction for Pcell or single cell case.
  + Proposal 6: For DL reception adaptation in the energy saving state (cell OFF),
    - RRC configures whether to monitor the PDCCH in a search space;
    - RRC configures whether to receive the SPS PDSCH per SPS configuration.
  + Proposal 7: For SR/CG PUSCH transmission adaptation for NWES during the energy saving state (cell OFF), study the following options:
    - Option 1) RRC configures whether to transmit the SR/CG PUSCH per configuration;
    - Option 2) UE does not transmit SR/CG PUSCH.
  + Observation 2: Legacy C-DRX results in large transition energy when gNB wakes up multiples times to process noncontiguous ON durations.
  + Observation 3: There is a tradeoff between NW energy savings and UE performance for C-DRX configuration. Current NR system requires large signaling overhead to adapt C-DRX configuration via RRC signaling per UE.
  + Proposal 8: Support UG-specific dynamic adaptation of C-DRX to align or concatenate the ON durations for NW energy saving:
  + Proposal 9: Support gNB wake up request under Pcell/PScell network energy saving state (cell OFF). The following options can be considered.
    - Option 1) UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request.
    - Option 2) UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
  + Proposal 10: The following channels can be considered to carry the gNB wake up request.
    - PUCCH with SR.
    - PRACH.
    - PUCCH with a new UCI type.
  + Proposal 11: MAC layer decides whether to trigger the transmission of gNB wake up request/UE assistance information.
  + Proposal 12: Consider the following changes to the TP for TR
    - Technique #A-1 Adaptation of common signals and channels
      * Network energy saving can be realized by flexibly varying the periodicity and/or dynamically changing a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or flexibly varying the periodicity of uplink random access opportunities.
        + This also include introducing light version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.
        + This is mainly for BS idle/inactive mode, e.g. cell deactivation without DL data transmission.
      * Support of burst transmission and reception of common signals and channels with more than one periodicity and/or adaptation of a burst pattern, including periodicity, are expected to potentially provide longer inactivity periods for the gNB and potentially provide higher power saving gains.
      * ~~Support of [dynamic adaptation of SSB/SIB transmission or] on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB and potentially provide energy savings.~~
        + ~~[This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA. and/or support offloading system information from one cell to another for inter-band CA.]~~
        + ~~This may include support of signals/channels to aid discovery of cells in lieu of SSBs.~~
        + ~~This may include support of mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.~~
        + ~~It should be noted that use of CA means the technique is only applicable to UEs in connected mode.~~
      * ~~[Support of scheduling enhancements for SIB1~~ along with a long period (rather than the period as the same as the SSB period) adaptation of CORESET 0 (e.g. in a separately configured CORESET) are expected to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB and potentially provide higher power saving gains.]
        + This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0
        + This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead
      * Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.
    - Technique #A-2: Dynamic adaptation of UE specific signals and channels
      * Network energy saving opportunities may be restricted by UE specific signals and channels that are semi-statically configured such as periodic or semi-persistent CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
      * Reducing the number of time occasions for the following resources during periods of low activity may potentially provide energy saving benefits.
        + CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
        + ~~This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.~~RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
      * ~~Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.~~
      * ~~Support of configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE/cell group-level or ccell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.~~
      * ~~The impact to the UE performance by adaptation of UE specific signal/channels should be included along with the network energy saving performance results.~~
    - Technique #A-3: wake up signal (WUS) for gNB
      * Support of wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), support of wake up signal (WUS) transmitted by the UE/neighboring gNB including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).
        + Whether UE detection of a dormant power state/energy saving state is required before WUS transmission should be identified.
        + Resource reserved for WUS and the assumption of the gNB receiver should be identified
        + This may include support of assistance information from the UEs intended to aid wake up operations by the gNBs.
        + Wake up signal (WUS) is triggerd by MAC layer.
      * This is mainly for connected mode UEs
      * Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.
      * The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.
      * UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
    - Technique #A-4: Adaptation of DTX/DRX
      * DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB.
        + This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
      * An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS.
      * The two techniques/approaches of DTX/DRX alignment can be complementary to each other and they may be beneficial to energy savings both at the network and at the UE side.
      * [Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time may potentially provide energy saving benefits, such as SSB or SIB.]
      * Reduction of periodically transmitted/semi-static configured channels/signals (e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time).
      * Controlling UE DRX on/off periods for multiple DRX cycles with a single indication can potentially provide longer inactivity periods at the gNB.
      * This may include group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced command MAC CE and long DRX commend MAC CE.
    - Technique #A-5: Adaptation of BS inactive state
      * Support of gNB entering into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration are expected to potentially provide flexible adaptation at the gNB and can potentially provide higher power saving gains.
        + This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
        + This may include group common signaling for the indication of adapted active/inactive state
        + If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.
* [24] Ericsson
  + Frequent Rx/Tx activities (e.g., periodic TRS or PRACH occasions) at low-moderate loads increases the network energy consumption.
  + Study and identify techniques minimizing periodic reference signal transmissions, e.g., enabling fully aperiodic TRS for FR1 and FR2 when needed.
  + Study and identify techniques which enable dynamic adaptation of PRACH and PUCCH occasions according to the need.
  + Study and identify techniques in which the UE can assist the network in optimizing its scheduling to maximize its sleep opportunities.
* [25] NTT Docomo
  + Proposal 1: Study CDRX and WUS for gNB for network energy saving techniques.
  + Proposal 2: Study SSB periodicity adaptation such as extended SSB periodicity for network energy saving techniques.
    - Trade-off between power saving gain and initial access and handover performance should be considered.
  + Proposal 3: Study SSB-less SCell for inter-band CA for network energy saving techniques.
* [26] Qualcomm
  + Observation 1: Network energy consumption in this scenario of “gNB in idle mode”, i.e., case of no or few PDSCH, PUSCH, CSI/RS, SRS transmissions, is mainly dependent on SSB transmission and associated downlink and uplink procedures for initial access and system information transmission.
  + Proposal 1: Capture in TR the following description with regards to the reduction/adaptation of transmission/reception of common channels/signals:
    - RAN 1 to focus the work on network energy saving mechanisms for Rel. 17 SSB beam sweeping on the “gNB in idle mode” scenario, i.e., scenario of very low load and in which the gNB activity is largely due to SSB transmission and RACH reception. SSB beam sweeping and associated signaling, e.g., paging, RACH reception is the highest energy contributor in the case of very low load in the cell.
  + Proposal 2: Capture in TR the following description with regards to the reduction/adaptation of transmission of common channels/signals includes:
    - Introducing simplified “light” version of downlink common and broadcast signals, such as SSB:
      * With the term “light SSB” what is meant is either PSS only or PSS and SSS.
      * SSB/”light SSB”, RMSI or paging as well as uplink random access opportunities can be skipped in time and/or spatial domain.
      * on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.
        + This may include UL channels and associated mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation
      * This is mainly useful for BS idle/inactive mode, e.g. for temporary cell switching off without DL data transmission, or in the case in which the BS is actively transmitting common broadcast signals but there is no DL data transmission.
  + Observation 2: Coordination of UE C-DRX configurations across multiple UEs may facilitate BS DTX/DRX implementation for network energy savings.
  + Proposal 3: Capture in TR the following description for semi-static and/or dynamic cell on/off:
    - DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle mode can potentially provide longer inactivity periods at the gNB.
      * This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
      * An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS. The mechanism of BS DTX in this case is identical to the one just described: the BS pauses DL transmission during DTX period. The difference with the DTX mechanism aligned with the UE DRX cycle is that this proposed mechanism here is that the BS DTX Pattern is initiated by the BS, without the BS necessarily considering the UE C-DRX patterns.
      * The techniques/approaches of DTX/DRX alignment can be complementary to each other.
      * This may include group level indication for, such as UE-group signaling or cell-specific signaling.
  + Proposal 4: Capture in TR the following description for dynamic C-DRX configuration adaptation
    - A UE may be configured with a C-DRX configuration for network energy savings in addition to a legacy C-DRX configuration. The C-DRX configuration for network energy savings can be common to a group of UEs. The UE may receive L1/L2 signalling to switch between the configured C-DRX configurations.
    - Specification impact at least includes L1/L2 signaling to switch between the configured C-DRX configurations (e.g., C-DRX periodicity and/or inactivity timer).
  + Observation 3: Cell wake-up mechanism could enable BS flexibly provision downlink channel transmission (e.g., broadcast channel) and uplink channel reception (e.g., RO, SR, and configured grant) to achieve network energy savings.
  + Observation 4: Cell wake-up mechanism might be applicable to a cell without any connected mode UE (empty scenario) and with some connected mode UEs (low load scenario).
  + Proposal 5: Capture in TR the following description for cell wake-up procedure
    - Cell wake-up procedure is a procedure in which a UE may send a cell wake-up request to help gNB transition from a sleep state to an active state. Furthermore, based on the received request, gNB may broadcast its active time to one or a group of UEs.
    - Specification impact may include cell wake-up request from UE, UE behaviour when base station is in sleep state, and indication of gNB active time.
* [27] ITRI
  + Proposal 1: The energy saving state(s) or sleep mode(s) may be defined for network energy saving.
  + Proposal 2: The following aspects for increasing time domain energy saving opportunities by the gNB can be considered:
    - Dynamic adaptation of UE C-DRX configurations according to the energy saving state(s) or sleep mode(s)
    - Dynamic adaptation of transmission/reception of common signals according to the energy saving state(s) or sleep mode(s)
* [28] CEWiT
  + Observation 1: Mandatory set operations consume energy at the gNB irrespective of the load.
  + Observation 2: Use of lighter version of SSB provides 46% and 11.2% energy saving for no load and low load scenarios.
  + Proposal 1: Support use of light versions of SSB at the gNB based on load.
  + Proposal 2: In case of use of lighter version of SSB by a gNB, study the mechanisms to inform the contents of PBCH to the UE.
  + Proposal 3: Adaptation of SSB periodicity at beam level is supported.
  + Observation 3: Scheduling of SIB1 using SSB will provide an energy saving of 24.06% when compared with scheduling of SIB1 using DCI 1\_0
  + Proposal 4: Scheduling of SIB1 using SSB is supported.
  + Proposal 5: Study mechanisms to overcome increase in size of SSB, scheduling SIB1

### [CLOSED] 1st Round Discussions

Companies should start thinking about what potential techniques to capture and what information would be captured together with the techniques. Moderator suggests refining the technique description further based on what was discussed in RAN1 #110. Discussion should include any suggestions to splitting or merging the techniques listed.

Please comment further on the following proposals, including comments to address notes from the moderator below.

#### Proposal #2-1

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-1 Adaptation of common signals and channels
  + Dynamically(1) vary the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity of uplink random access opportunities.
    - This also include introducing simplified version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.(2)
    - This is mainly for BS idle/inactive mode(3), e.g. cell deactivation without DL data transmission.
  + burst transmission and reception of common signals and channels with more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB.
  + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.
    - This may include signals/channels(5) to aid discovery of cells in lieu of SSBs.
    - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.
    - It should be noted that use of CA means the technique is only applicable to UEs in connected mode.(6)
  + adaptation of CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB]
    - This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0(7)
    - This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead(8)
  + Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.(9)

Notes from the moderator on above:

* Note (1) Need to Clarify (enough to be able to be evaluated by companies)
  + May clarify that whether this is automatically changed by BS or with the aid of DL indication
  + May clarify what is the transmission pattern referring to and when exactly it may be applicable, e.g. for which channel at what conditions.
* Note (2) Need to Clarify (enough to be able to be evaluated by companies)
  + clarify how it is light/simplified may need to be clarified or be reported.
  + clarify which specific channel or signal does this technique target? Or mixed, i.e. for some occasion, SSB is skipped and for some other occasions, SIB is skipped?
  + The former part “light version” seems to explain the channel itself is modified/simplified while the later part seems to say the configuration of such channel is modified. It is unclear whether one or both modifications are part of the technique.
* Note (3) Need to Clarify (enough to be able to be evaluated by companies)
  + Since there is no definition for BS idle/inactive, may clarify whether this is intended from UE perspective, otherwise may need to clarify/modify the terminology.
* Note (4) Need to Clarify (enough to be able to be evaluated by companies)
  + Since the previous bullet also includes change of periodicity, is the difference at a given time there can be multiple periodicities available to UE and UE can choose one of them without e.g. DL indication?
  + May clarify which specific channels this technique target.
* Note (5) Need to Clarify (enough to be able to be evaluated by companies)
  + DL or UL? If this intends to be a UL channel, can this be part of the next sub-bullet, i.e. the one used by “UE to trigger”?
* Note (6) Need to Clarify (enough to be able to be evaluated by companies)
  + If it is for CA, more proper to be placed in frequency domain.
* Note (7) Need to Clarify (enough to be able to be evaluated by companies)
  + CORESET0 does not seem to have periodicity today. Is it intend to say Search Space?
* Note (8) Need to Clarify (enough to be able to be evaluated by companies)
  + The former part may be used to replace the main bullet of this technique as clear for evaluations
  + The latter part may be clarified as part of the same technique (in this case, it could also be part of details for companies to report) or another technique as a separate bullet.
* Note (9)
  + May belong to performance/impact analysis, instead of technique description

#### Company Comments on Proposal #2-1

|  |  |
| --- | --- |
| Company | Comments |
| Xiaomi | For Note (7), since we proposed the related solution, it is intend to say Search Space 0. |
| DOCOMO | Regarding the last bullet “Dynamic adaptation of the periodicity…”, it seems related only for the first bullet with the current description. It should be moved into the first bullet about dynamic adaptation of periodicity of common/broadcast signals/channels. Or, it should be more generalized or updated to cover all the potential techniques in #A-1. |
| CMCC | * For the first sub-bullet of the Technique A-1, we think there are different realizations, as shown in the following figure, it gives example of varing the transmission of SSB/SI/cell common PDCCH.      * For alt.1 and alt.3, they can be categorized to adapting the periodicity of downlink common and broadcast signals, such as SSB/SI/cell common PDCCH. * For alt.2, it changes the pattern of SSB, and also it change the periodicity of downlink common and broadcast signals * And “vary” or “adapt” means the periodicity can be changed based on UE request or by gNB and may be indicated to UE to save UE power. * For the second note of the FL, it can be split into two sub-bullet, one is about the simplified version and the other is about different repetition period of common channels. As show in above figure, alt.1. * For the third note, we think this is not limited to idle/inactive state, for example, when applying to Scell, the gNB has connected UEs. * For the fourth note about the second sub-bullet, we also think “with more than one(4) periodicity” need to be clarified. To our understanding, when adapting the periodicity of common channels/signals, it also means there will be more than one periodicity. * For the third sub-bullet, when SSB/SIB1-less operations is introduced for some carriers, according to current specification, such carriers can not be used for initial access, which may cause initial access congestion. To solve such problems when keeping the power saving benefit of SSB/SIB1-less, enhancement can be made for UE to access such carrier with assistance information(SSB/SIB1) from other carriers.   In practical, a gNB can have multiple carriers, while the UEs it serves can work at a single carrier or multiple carriers mode. To realize power saving of gNB on one carrier, SSB/SIB1 needs to be reduced for such carrier, regardless of whether it is Scell of one UE or the serving cell of other UEs without CA capability. Some UEs work at a single carrier mode, but the carrier they get connected is not the carrier where they get system information. For such carriers, UE needs assistance information from other carriers to work with such carrier.  So this is not only limited to connected mode, it can also apply to idle/inactive mode for initial access.  So we prefer the following modification for Technique #A-1   * Technique #A-1 Adaptation of common signals and channels   + Dynamically(1) ~~vary~~adapt the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity of uplink random access opportunities.     - This also includes introducing simplified version of downlink common and broadcast signals, such as PSS/SSS without PBCH.     - This also includes different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH.~~where for some periodicity occasion one or more common signals/channels can be skipped.~~~~(2)~~     - ~~This is mainly for BS idle/inactive mode~~~~(3)~~~~, e.g. cell deactivation without DL data transmission.~~   + burst transmission and reception of common signals and channels with more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB.     - Comment: the difference between this and the first sub-bullet needs to be clarified. To our understanding, adapting the periodicity of common channels/signals also means there will be more than one periodicity.   + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.     - This may include signals/channels(5) to aid discovery of cells in lieu of SSBs.     - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - This may include cross carrier synchronization and system information enhancement to provide other carriers’ information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.     - ~~It should be noted that use of CA means the technique is only applicable to UEs in connected mode.~~~~(6)~~ |
| Lenovo | Note (1): Rel-18 UE would benefit from DL indication for a change, regarding initial access procedure.  “Dynamically varying the periodicity and/or dynamically changing transmitted SSBs in a SSB burst and corresponding PDCCHs/PDSCHs for SI/paging, and/or varying the periodicity of uplink random access opportunities, with assistance of DL indication.”  Note (3): In our view, dynamic change of SSB transmission patterns and indication is also applicable to low-load scenarios. For Rel-18, can define BS idle/inactive mode, where the BS transmits only SSBs, minimum system information (e.g. SIB1 or simplified SIB1), and/or paging.  Note (4): “Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, are expected to potentially provide longer inactivity periods for the gNB.”  Note (9): we agree it should be under performance/impact analysis. |
| vivo | Our comments are provided inline below:   * Technique #A-1 Adaptation of common signals and channels   + Dynamically(1) vary the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity of uplink random access opportunities.     - This also include introducing simplified version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.(2)     - This is mainly for BS idle/inactive mode(3), e.g. cell deactivation without DL data transmission.   **[vivo] Agree that the details on how to vary the transmission pattern should be clarified by proponent. Otherwise, transmission pattern in this bullet should be removed.**   * + burst transmission and reception of common signals and channels with more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB.   **[vivo] Seems already included in the above bullet and suggest to remove this bullet.**   * + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.     - This may include signals/channels(5) to aid discovery of cells in lieu of SSBs.     - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - It should be noted that use of CA means the technique is only applicable to UEs in connected mode.(6)   **[vivo] The mentioned technique here is mainly for single carrier case. When there is no any data or no connected UEs, gNB may enter into SSB/SIB1-less operation and UE can trigger on-demand SSB/SIB1 transmission when needed. Suggest to remove the last bullet.**   * + adaptation of CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB]     - This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0(7)     - This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead(8)   + Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.(9) |
| LG Electronics | Note (1): In our view, periodicity or transmission pattern can be changed based on gNB’s configuration/indication. Regarding transmission pattern, our understanding is that some of SSB indexes or SIB1/RO corresponding to some of SSB indexes can be omitted or invalidated depending on the periodicity. For example, in this period, SSB indexes #A/B/C/D are transmitted while SSB indexes #A/B/C are transmitted in the next period. In addition, we prefer Flexibly (which seems to be more general) rather than Dynamically, since “dynamically” may imply that periodicity can be varied by DCI indication but other methods should not be precluded during study item phase.  Note (3): Agree with the moderator that BS idle/inactive mode is unclear. The corresponding bullet can be removed.  Note (5): In our understanding, this signals/channels are from DL and its original intention was not related to on-demand SSB/SIB but to simplified/light version of SSB.  We request a clarification on the following bullet. It is questionable how on-demand SSB/SIB1 transmission can support faster access/faster cell activation compared to legacy initial access procedure (for which SSB/SIB1 is transmitted periodically).   * + - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.   Note (9): General question to the moderator, will we focus on technique description for proposals in this summary? Will we separately discuss UE impact for each identified NW energy saving techniques? |
| ZTE, Sanechips | 1. For the first bullet, i.e., varying common signal/channel periodicity/pattern, we think the solution is not limited to “cell deactivation without DL data transmission ”, the case that the cell with RRC connected states UEs can be also considered. Furthermore, the BS idle/inactive mode is not clear. Therefore, we suggest to remove the following bullets.    * + ~~This is mainly for BS idle/inactive mode~~~~(3)~~~~, e.g. cell deactivation without DL data transmission.~~ 2. For the following bullet, we agree with CMCC that the first bullet includes the case that there are multiple periodicity for common signal/channel, so that the varying pattern/periodicity can be implemented. Therefore, we suggest to keep the following bullet as a sub-bullet of “vary the periodicity and/or a transmission pattern ”    * burst transmission and reception of common signals and channels with more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB. 3. For the following bullet, we think the case that UE configured with CA should not be precluded. The difference between the following bullet and the solution is frequency domain is that the solution in frequency domain is specific to SCell. While the following solution can be applicable to either PCell or SCell. Moreover, some update is suggested on top of CMCC’s version.    * on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.      + ......      + This may include cross carrier synchronization and system information enhancement to provide other carriers’/cells’ information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.      + This can be applied to UEs in RRC idle/inactive/connected state. It should be noted that use of CA means the technique is only applicable to UEs in connected mode.(6) 4. The CORESET is more of a term in frequency domain. Not sure whether it is intended for common search space. If the answer is yes, it can be included in the first bullet, or as a sub-bullet. 5. For the adaptation of common signals and channels, WUS mechanism can be used to trigger variation of the periodicity/transmission pattern of DL common and broadcast signals, on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations. Therefore, WUS mechanism is proposed to be considered . Some suggestions are as below.    * Dynamically(1) vary the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity of uplink random access opportunities.      + This also include introducing simplified version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.(2)      + The varying periodicity and/or a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.      + .....    * on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.      + This may include signals/channels(5) to aid discovery of cells in lieu of SSBs.   This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement. |
| Fraunhofer | Addressing Note (5), we consider this to be DL signaling and suggest following edit to the sub-bullet:   * + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.     - This may include DL signals to aid initial access and discovery of cells in lieu of SSBs.   Agree with Note (6)  Addressing Note (9) and based on arguments elaborated in [19], we propose the following modification by including an associated technique and prefer to keep it as part of technique description:   * + Since the reduction of common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, and legacy UE network access, techniques to mitigate such impact should be evaluated     - Reduction of common channel/signals can be, for example, via dynamic adaptation of SSB/SIB1 periodicity or on-demand SSB/SIB transmission     - The techniques may include utilizing simplified DL signals in lieu of SSBs or prior to SSBs to improve the initial access process significantly while enabling network energy saving.     - The techniques may include defining DL signals (e.g., a System Presence Indicator) that indicates to the UEs the presence of gNBs transmitting SSBs within a limited block of frequency positions in order to improve initial access performance. |
| Huawei, HiSilicon | For Technique A-1, we think the on-demand SSBs/SIB1 transmissions and SSS/SIB1-less operation are two techniques. It would be unclear regarding which sub-bullet describes the characteristic for on-demand SSBs/SIB1 or SSB-SIB1-less transmission. Therefore, we update the description into two separate parts. Some other revisions are made to resolve the notes from moderator and give more clear explanation of the solution, e.g. whether it applies to CA or non-CA case. Also, wel think we could add the wording of “which is feasible from RAN1 perspective”. If the group finds some solution is not feasible from RAN1 perspective, we should not capture the solution. Some revisions are made as following:   * Technique #A-1 Adaptation of common signals and channels, which is feasible from RAN1 perspective, including:   ……skipped text……   * + on-demand SSBs/SIB1 transmissions ~~or~~ ~~SSB/SIB1-less operations~~ may also enable long periods of inactivity at the gNB.     - This may include DL signals/channels(5), e.g. simplified version of SSB, to aid discovery of cells in lieu of SSBs.     - This ~~may~~ includes mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - ~~It should be noted that use of CA means the technique is only applicable to UEs in connected mode.~~~~(6)~~   + SSB/SIB-less operations may also enable long periods of inactivity at the gNB.     - This may include DL signals/channels~~(5)~~, e.g. simplified version of SSB, to aid discovery of cells in lieu of SSBs.     - This includes offloading SIB of the SIB-less cell to another cell.     - Note: the SSB-less operation is used for inter-band CA case and SIB-less operation is for non-CA case. |
| Fujitsu | For Note (6), we agree that the description about CA operation should be moved to frequency domain. The techniques in time domain should focus on single carrier operation. |
| Samsung | * Note 1: The transmission pattern includes the position of actual SSB transmission for a given transmission periodicity. * Note 3: It is from UE perspective. * Note 6: The bullet for CA can be merged into the frequency domain, e.g., Technique #B-1. * Note 7: same view as FL * Note 9: agree with FL. In addition, it is not limited to ‘periodicity’ adaptation, but applies entire ‘#A-1’.   We suggest the following update highlight yellow. Proposal #2-1 The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.  Technique #A-1 Adaptation of common signals and channels   * + Dynamically(1) vary the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity of uplink random access opportunities.     - This also include introducing simplified version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.(2)     - This is mainly for BS idle/inactive mode(3), e.g. cell deactivation without DL data transmission.   + burst transmission and reception of common signals and channels with more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB.   + ~~on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.~~     - ~~This may include signals/channels~~~~(5)~~ ~~to aid discovery of cells in lieu of SSBs.~~     - ~~This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.~~     - ~~It should be noted that use of CA means the technique is only applicable to UEs in connected mode.~~~~(6)~~ |
| Intel | We suggest following revision to the descriptions of the bullet based on some of the notes:   * + Dynamically(1) or semi-statically vary the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity of uplink random access opportunities.     - This also include introducing simplified version of downlink common and broadcast signals, where for some periodicity occasion of one or more common signals/channels can be skipped.(2) or configuring the resource allocation pattern such that common signals are nearly back to back (e.g. nearly consecutive).     - This is mainly for BS idle/inactive mode(3), e.g. ~~cell deactivation~~ without DL data transmission     - Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly ROs can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.     - Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.   Note(1) Agree with moderator that further details of what is dynamically changing and how is needed (at least on a high-level).  Also, we think we should consider to split the technique into two different techniques, as too many sub-features are bundled together. For example, the following bullets can be categorized as Technique #A-1b. We also suggest removing the last bullet with Note (9).   * + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.     - This may include signals/channels(5) to aid discovery of cells in lieu of SSBs.     - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - It should be noted that use of CA means the technique is only applicable to UEs in connected mode.(6)   + adaptation of CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB]     - This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0(7)     - This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead(8)   ~~Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.~~(9) |
| CEWiT | For Note (1), A DL indication is needed for variation in periodicity, it will help the connected UEs to avoid unnecessary monitoring of signals/channels, which are skipped due to change in periodicity. Also, since in current NR, the periodicities of all SSB indices in a burst are same and if an SSB is absent, it will be absent for full SIB1 periodicity. Hence to deal with different user activity, variation in periodicity for an SSB should be supported. This variation of periodicity can also be semi static, where different SSB indices with different periodicites can be configured through RRC. Thus, We suggest to remove the term “Dynamically” from the sub bullet and prefer Flexibly, since “dynamically” may imply that periodicity can be varied by DCI indication but other methods should not be precluded during study item phase.  For Note (2), Simplified means a DL signal/channel occupying less time & frequency resources than their conventional versions. For e.g. Specifically for SSB, a simplified SSB contains partial contents instead of full SSB. Also, the part “where for some periodicity occasion one or more common signals/channels can be skipped” is already covered in main sub bullet, hence its redundant and can be removed.  For Note (3), This is intended to BS with no/low load, hence it can be modified as “This is mainly for BS with empty/low load, e.g. cell without DL data transmission.”  For Note (4), Previous bullet is specifically for variation of periodicity of common signals and channels, however this bullet specifically talks about multiple periodicities at a time for a burst, for e.g. an SSB burst having different beams with different periodicities. This technique should atleast be applicable for SSB burst.  For Note (5), Its DL signals/channels, since some relaxed version of SSB can be used by UE to synchronize with the BS before transmitting the UL trigger. It can also be used for measuring the channel quality before sending the trigger.  For Note (8), we agree with the moderator to make the former part a main bullet and latter part as a sub-bullet. Thus, we suggest to split and modify the bullet as shown below in suggested updates for the technique A-1.  Thus we suggest following updates for proposal 2-1. Proposal #2-1  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #A-1 Adaptation of common signals and channels   + ~~Dynamically~~~~(1)~~Flexibly vary the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity of uplink random access opportunities.     - This may include DL signalling to indicate the variation of periodicity.     - This also include introducing simplified version of downlink common and broadcast signals for e.g., an SSB with partial contents of SSB instead of full SSB.~~, where for some periodicity occasion one or more common signals/channels can be skipped~~.(2)     - ~~This is mainly for BS idle/inactive mode~~~~(3)~~~~, e.g. cell deactivation without DL data transmission.~~This is mainly for BS with empty/low load, e.g. cell without DL data transmission.   + burst transmission and reception of common signals and channels with more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB for e.g., an SSB burst with different periodicities among beams.   + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.     - This may include DL signals/channels(5) to aid discovery of cells in lieu of SSBs.     - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - It should be noted that use of CA means the technique is only applicable to UEs in connected mode.(6)   + adaptation of CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB]     - This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0(7)     - ~~This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead~~~~(8)~~   + Scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0.     - This may include support of the mechanism to reduce impacts on SSB and overhead(8)   + Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.(9) |
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| QCOM1 | No support for dynamic adaptation of common channels, since this will have an impact on legacy UEs and on UEs in idle mode.  “Light SSB” is the SSB that contains only PSS. The UE upon detection of PSS, transmits cell WUS and the network transmits SSB, i.e. PSS, SSS, MIB, SI.  This is the first technique that combines “light SSB” together with cell WUS.  Another (second) technique is the compact SSB, which means that there are no gaps – which would otherwise have been used for PDSCH – between SSB bursts. Both techniques are a part of this proposal. They can be combined.  The term “BS idle/inactive” (or “gNB idle/inactive”) implies that there is no DL data transmission, i.e. no PDSCH and associated CSI-RS transmission to UEs in the cell; or otherwise, there no UEs in RRC connected mode in the cell.  With regard to the signal aiding the discovery of a cell and replacing SSB, what was meant was the “light SSB” which is consisted of PSS only. |
| Apple | Note (1): we also think it should be clarified whether this is an autonomous behavior by BS or with some indication to the UE. If it is the latter, the signaling impact can be added as one of the sub-bullets. Elaboration on “Transmission pattern” is also important.  The difference between the first and second bullets is not clear to us. Both are introducing some dynamic adaptation of the common siginals/channels transmission.  For the 3rd bullet, whether it is intended for CA should be clarified. |
| CATT | WE are OK the description of NES techniques in Proposal#2-1 by Moderator. The final text should be revised with the general procedures (high-level physical layer procedures and/or higher layer procedure) , complexity analysis, and impact to UE network access, in particularly legacy UEs. |
| InterDigital | On Note 1, the transmission patterns of DL common and broadcast signals may be related to, for example, a configured subset of SSBs and periodicities associated with the SSB subset. The UE can determine the transmission pattern of the DL signals based on dynamic indication or autonomous detection. |
| Ericsson1 | 1st bullet : suggest to add availability of uplink random-access opportunities.  3nd bullet, it is not clear how the last bullet regarding CA is to be read. If the technique itself is linked to CA, for example, why on-demand SIB1 is needed for a connected mode UE? is it for fast access to SCell ? We suggested some updates below, but OK to clarify in another way.  For last bullet, there are other impacts as well that should be listed.  Our suggested updates are as follows:   * + Dynamically(1) vary the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities.     - This also include introducing simplified version of downlink common and broadcast signals, where for some periodicity occasionone or more common signals/channels can be skipped.(2)     - This is mainly for BS idle/inactive mode(3), e.g. cell deactivation without DL data transmission.   + burst transmission and reception of common signals and channels with more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB.   + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.     - This may include signals/channels(5) to aid discovery of cells in lieu of SSBs.     - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - This technique utilizes carrier aggregation mechanism and it should be noted that use of CA means the technique is only applicable to UEs in connected mode.(6)   + adaptation of CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB]     - This may include support of a long period (rather than the period as the same as the SSB period) of CORESET 0(7)     - This may include support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead(8)   + Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.(9) |
| OPPO | Regarding the third sub-bullet, we share the same view with other companies that on-demand SSBs/SIB1 transmissions and SSB/SIB1-less operations should be separate techniques. With SSB/SIB1-less operation, when a UE is trying to access an SSB/SIB1-less carrier, it can obtain SSB/SIB1 or other system information from another carrier. From UE perspective, the access latency on the SSB/SIB1-less carrier can be reduced, and from gNB perspective, energy saving gain can be achieved.  We propose some modifications on this sub-bullet:   * + on-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.     - This may include signals/channels(5) to aid discovery of cells in lieu of SSBs.     - This may include mechanism for UE to trigger on-demand SSB/SIB1 transmission for fast access/fast cell activation.     - It should be noted that use of CA means the technique is only applicable to UEs in connected mode.(6)     - This may include offloading SSB/SIB1 or other system information from one cell to another cell. |

#### Proposal #2-2

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing the number of time occasions for the following resources during periods of low activity (10)
    - CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS). (10)
    - This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.
  + Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.(11)
  + configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE(12)/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
  + The impact to the UE performance by adaptation of UE specific signal/channels should be included along with the network energy saving performance results.(13)

Notes from the moderator on above:

* Note (10) Need to Clarify (enough to be able to be evaluated by companies)
  + Needs to be specific with techniques, e.g. on how to reduce the occasions on which channel(s).
  + If there are general applicability of various channels, it might be representative to prioritize some for study.
* Note (11) Need to Clarify (enough to be able to be evaluated by companies)
  + need details otherwise can be supported by existing specifications
* Note (12) Need to Clarify (enough to be able to be evaluated by companies)
  + May need details otherwise can be supported by existing specifications
* Note (13) belong to performance/impact analysis, instead of technique description

#### Company Comments on Proposal #2-2

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| Company | Comments |
| CMCC | For the UE specific channels and signals, downlink can be prioritized.  For uplink, when CSI-RS is reduced, the CSI report will be reduced correspondingly. And the PUCCH carrying HARQ-ACK for SPS is only needed when there is SPS PDSCH.  The following sentence seems to be incomplete, and can be modified,   * + Support reducing configuration signaling of the UE specific signals and channel transmission and reception ~~to be reduced~~, e.g. by utilizing UE(12)/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity. |
| vivo | Our comments are inline below:   * + Reducing the number of time occasions for the following resources during periods of low activity (10)     - CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS). (10)     - This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.   [vivo] How to reduce the time occasions is not clear. Besides, UE buffer status report is a legacy signaling. Suggest to remove this bullet   * + Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.(11)   [vivo] Agree with Note (11). Suggest to remove this bullet.   * + configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE(12)/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.   [vivo] This group-level or cell-level signaling will apply to all signals and channels, or just part of them? If part of them, which signal or channel will use this> |
| LG Electronics | Note (10): In our view, Technique #A-2 can be merged with Technique #A-5. By gNB informing NES state for a certain duration, UE will not receive DL signal/channel or will not transmit UL signal/channel for the duration. We don’t think we need to pick up any representative signal/channel for this technique.  Note (12): Which existing specifications are you referring to for reducing transmission and reception of UE specific signal/channel? As we stated above, with Technique #A-2 and #A-5 combined, a UE can be informed by group-common signaling that the UE is not required to receive DL signal/channel or transmit UL signal/channel for a certain duration. |
| ZTE, Sanechips | In general, we agree with moderator’s notes. Some suggestions as below.   * + ~~Support of~~ enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB ~~can be considered~~.(11) |
| Fujitsu | We agree with Note (12) that utilizing UE specific configuration signaling can be removed since it is already supported by existing specifications. |
| Samsung | * Technique #A-2 can work together with Technique #A-5, RRC can configure whether to receive/transmit a channel per configuration when gNB is in sleep mode. * BSR is a RAN2 issue, suggest to remove ‘This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.’ * Note 13: The last bullet is not related to techniques and suggest to remove.   We suggest the following update highlight yellow. Proposal #2-2  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Reducing the number of time occasions for the following resources during periods of low activity (10)     - CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS). (10)     - ~~This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.~~ RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.   + Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.(11)   + configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE(12)/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.   + ~~The impact to the UE performance by adaptation of UE specific signal/channels should be included along with the network energy saving performance results.~~~~(13)~~ |
| Apple | Note (11): agree.  We also propose to add one sub-bullet for the following:  “Support of group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals” |
| CATT | We have our reservation of Proposal 2-2 as the placeholder before the power model and scaling is completed. In current state of power model and power scaling for NES, the active state has the general power consumption averaged over a slot. The reduction of the UE specific signals/channels would have the impact of network access latency and the performance. The note (13) should be the required condition for the proposed NES techniques to justify the potential NES gain. |
| InterDigital | On note 11, this is addressed by the description in the 3rd sub-bullet " UE(12)/cell group-level or cell common signaling to allow gNB”, which is better described under Technique #A-5.  We also suggest capturing the impacts to legacy UEs in Proposal #2-2 as follows:   * Legacy UEs are not able to use resources in all network energy saving states. |
| Ericsson1 | Our suggested updates are as follows:   * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Reducing/omitting the number of time occasions for one or more of the following resources during periods of low activity (10)     - CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS). (10)     - This may include report of UE assistance information, e.g., UE buffer status to help gNB make decisions.   + Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.(11)   + configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE(12)/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.   + The impact to the UE performance by adaptation of UE specific signal/channels should be included along with the network energy saving performance results.(13) |
| OPPO | Regarding the first sub-bullet, to help gNB make decisions on reducing the time occasion number for periodic configurations, the UE can also directly report the activation or deactivation request based on its buffer status. We propose the following updates:   * + Reducing the number of time occasions for the following resources during periods of low activity (10)     - CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS). (10)     - This may include report of UE assistance information, e.g., UE buffer status or activation/deactivation request, to help gNB make decisions. |

#### Proposal #2-3

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-3: wake up signal (WUS) for gNB(14)
  + wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE/neighboring gNB(15) including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).
    - Whether UE detection of a dormant power state/energy saving state is required before WUS transmission should be identified.(16)
    - Resource reserved for WUS and the assumption of the gNB receiver should be identified (16)
    - This may include support of assistance information from the UEs intended to aid wake up operations by the gNBs.
  + This is mainly for connected mode UEs(17)
  + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.
  + The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.

Notes from the moderator on above:

* Note (14) Need to Clarify (enough to be able to be evaluated by companies)
  + This does not seem to be a standalone technique as itself does not provide energy savings for networks.
  + Can be considered as part of previous techniques, as need of UE assistance information
* Note (15) Need to Clarify (enough to be able to be evaluated by companies)
  + clarify the difference with existing implementation based approaches.
* Note (16)
  + belong to performance/impact analysis, instead of technique description
* Note (17) Need to Clarify (enough to be able to be evaluated by companies)
  + When incorporating A-3 to be part of other techniques, this sentence shall be further revisited.

#### Company Comments on Proposal #2-3

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| Company | Comments |
| CMCC | We think the WUS signal for gNB is a specification enhancement for gNB DTX or DRX. Since during the DTX or DRX, gNB can not react in time for UE traffic, and UEs can wake up gNB from such state and get served.  And UE in idle/connected mode can also wake up gNB as long as it can get wake up signal configuration. For example, UE can be RRC released by the gNB and informed that the gNB will go to inactive state. When UE finds it has traffic to be transmitted, it can wake up gNB by sending WUS. The WUS signal configuration can be configured to UE during the RRC release procedure, and it can also provide by neighbouring gNB.  So we propose to move it to proposal#2-4. |
| vivo | For Note (14), we suggest to rename the technique as “Wake up of energy saving gNB triggered by UE WUS”. In legacy case, gNB will send normal common signal such as SSB/SIB1 and monitor normal RACH even when there is no any data or connected UEs. Since the time when UEs have need of the SSB/SIB1 reception or RACH transmission is random, gNB can’t switch to energy saving state (i.e. no or sparse SSB/SIB1 transmission and RACH monitoring) if without UE WUS mechanism. On the other hand, UE WUS mechanism enables more gNBs to be in energy saving state without much performance loss, which provide energy savings for networks.  For Note (15), wake up of energy saving gNB by neighbor gNB is already implemented and specified in TS 28.310. Suggest to remove neighboring gNB here.  For Note (17), suggest to remove the sentence since UE WUS can be used for both idle and connected UEs. |
| LG Electronics | Note (14): We agree with the moderator in that this technique may not be a stand-alone technique. It can be absorbed to Technique #A-1 and/or Technique #A-2. To be specific, when gNB in NES state does not transmit common or UE-specific signals/channels, UE can request to gNB to transmit those signals/channels by transmitting WUS for gNB.  Note (15): We also think that gNB can wake up based on signaling from neighboring gNBs, according to current specification. If this is the correct understanding, we can remove “neighboring gNB” in that bullet.  Note (17): Our concern for this technique is that if this is combined with Technique #A-1, e.g., on-demand SSB, UE may not be able to determine reference DL timing and WUS power since SSB has not been received by the UE before transmitting WUS. In that sense, we think at least SSB should be received by UE before transmitting WUS for gNB, in case WUS can be associated with other NW energy saving techniques. |
| ZTE, Sanechips | We think the Proposal #2-3 can be also considered in the proposal 2-1 for common signal/channel adaptation, proposal 2-2, 2-4. Some suggestions has been made above. |
| Fraunhofer | Addressing Note (17), we suggest the following modification to the corresponding bullet:   * + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.   We propose to add following bullets to the description of the WUS, based on arguments elaborated in [19]:   * + DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.   + The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms). |
| Samsung | * Wake up signal (WUS) for gNB should be triggerred by MAC layer. * UE behavior after transmitting WUS should be included, the following two options can be considered.   + Option 1) UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request.   + Option 2) UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.   We suggest the following update highlight yellow. Proposal #2-3  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #A-3: wake up signal (WUS) for gNB(14)   + wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE/neighboring gNB(15) including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).     - Whether UE detection of a dormant power state/energy saving state is required before WUS transmission should be identified.(16)     - Resource reserved for WUS and the assumption of the gNB receiver should be identified (16)     - This may include support of assistance information from the UEs intended to aid wake up operations by the gNBs.     - Wake up signal (WUS) is triggerd by MAC layer.   + This is mainly for connected mode UEs(17)   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.   + UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request. |
| Apple | Note (14): agree that this does not seem to be a standalone technique. Since the design may be different depending on which technique it is combined with, it may be better to merge into other techniques so that each technique is a complete solution by itself. |
| CATT | Proposal#2-3 should make the assumption of UE synchronization with gNB in the dormant power state. The UE WUS proposal is for UE having the serving cell of neighboring gNB to send WUS in triggering wakeup of gNB in dormant power state. However, the transmission of UL signals/channels are based on the UE DL synchronization with the given cell with TA command for dedicated channels (PUSCH/PUCCH/SRS/synchronized RACH) or without TA command (asynchronized RACH). If UE is not synchronized with gNB in dormant power state, how would UE transmit the WUS to trigger wakeup of gNB in dormant power state. |
| InterDigital | For note (17), we suggest revising the wording to the following:   * this technique is more applicable to connected mode UEs, but can also apply to some idle/inactive UEs (17)   We also suggest capturing the specification impacts of Technique#A-3 in Proposal #2-3 as follows:   * Specification impacts may include design of WUS and conditions for triggering WUS transmission. |

#### Proposal #2-4

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle mode can potentially provide longer inactivity periods at the gNB.
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
  + An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS. (18)
  + The ~~two~~ techniques/approaches of DTX/DRX alignment can be complementary to each other .
  + [Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time such as SSB or SIB.](19)
  + Reduction of periodically transmitted/semi-static configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time).(19)
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication which can potentially provide longer inactivity periods at the gNB.
  + This may include group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced command MAC CE and long DRX commend MAC CE.

Notes from the moderator on above:

* Note (18) Need to Clarify (enough to be able to be evaluated by companies)
  + Some clarification may be preferred, as there is no BS DTX today and if used, as in the first bullet, it shall be defined first. Therefore it could be same/part of the previous technique.
* Note (19) Need to Clarify (enough to be able to be evaluated by companies)
  + May need clarification of the relationship of the two bullets/techniques

#### Company Comments on Proposal #2-4

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| Company | Comments |
| CMCC | DTX and DRX of gNB corresponds to inactive time during which gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, then the power consumption can be reduced.  Our modification proposal is as following, with wake up signals moved here, and since it can only applied to idle/inactive mode UE as commented under Proposal#2-3, we delete the corresponding sentence.   * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, then the power consumption can be reduced.   + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle mode can potentially provide longer inactivity periods at the gNB.     - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.   + An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS. (18)     - Comment: this bullet overlap with the first one, can be deleted.   + The ~~two~~ techniques/approaches of DTX/DRX alignment can be complementary to each other .     - Comment: does this mean DTX and DRX can be used both standalone and complement to each other?   + [Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time such as SSB or SIB.](19)     - Comment: this is included in the first new added sub-bullet.   + Reduction of periodically transmitted/semi-static configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time).(19)     - Comment: this is included in the first new added sub-bullet.   + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication which can potentially provide longer inactivity periods at the gNB.   + This may include group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced command MAC CE and long DRX commend MAC CE.   + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE/neighboring gNB(15) including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).     - Whether UE detection of a dormant power state/energy saving state is required before WUS transmission should be identified.(16)     - Resource reserved for WUS and the assumption of the gNB receiver should be identified (16)     - This may include support of assistance information from the UEs intended to aid wake up operations by the gNBs.     - ~~This is mainly for connected mode UEs(17)~~     - The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area. |
| vivo | From proper configuration, BS could achieve DTX/DRX cycle by implementation. The benefit of spec-involved DTX/DRX should be clarified. |
| Nokia/NSB | We would like to confirm our understanding that an indication of network DTX/DRX mode/pattern to the UE is already covered in Proposal #2-4. Further, we wonder whether such indication should be made explicit / broader compared to the current bullet points, which provide details on how the signaling for such indication can be defined (group-common, related to multiple UE DRX On-durations cycles, etc.).  We also noticed a typo on the last sub-bullet:  “o This may include group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced command MAC CE and long DRX ~~commend~~ command MAC CE.” |
| LG Electronics | Note (18): Regarding terminology DTX/DRX, we think it should be written from UE perspective. So, we propose to use the term “UE NES-DRX” to differentiate from legacy UE DRX. We also propose to deprioritize our discussion on gNB’s DRX.  Note (19): Those two bullets/techniques seem to be duplicated. |
| ZTE, Sanechips | * + An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS. (18)   [ZTE] this bullet is duplicated and can be removed.   * + The ~~two~~ techniques/approaches of DTX/DRX alignment can be complementary to each other .   [ZTE] More clarification is appreciated. For example, does it mean gNB’s DTX and DRX can be aligned?   * + [Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time such as SSB or SIB.](19)   [ZTE] this bullet is duplicated and can be removed.   * + Reduction of periodically transmitted/received/semi-static configured channels/signals(e.g. SSB, SIB, CG PUSCH, RO etc.), during the longer inactivity periods (~~i.e.~~ e.g. outside UE’s DRX active time/ within gNB’s DRX/DTX period).(19) |
| Samsung | * If the proposal works for IDLE mode, it can work for INACTIVE as well. * Note 18: Similar with above ‘Note 3’, it can be ended up with UE perspective description.   We suggest the following update highlight yellow. Proposal #2-4  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/ inactive mode can potentially provide longer inactivity periods at the gNB. |
| Intel | Suggest to add the following to A-4.   * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle mode can potentially provide longer inactivity periods at the gNB.     - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.     - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the BS.     - Joint or separate configuration of DTX and DRX mode at the gNB |
| QCOM1 | The term BS DTX implies that the UE pauses transmission for a short period of time, e.g. for a few ms and the BS goes to micro sleep or light sleep, and then the BS returns back to active DL. During this BS Tx Inactivity period, i.e., when the UE pauses DL transmission, PDSCH, PDCCH, NZP CSI-RS, TRS is not transmitted in the cell.  The BS does not pause DL transmission when the BS is scheduled to transmit SSB.  The “BS autonomous” triggering of BS DTX can be triggered by the BS, without having previously aligned UEs’ C-DRX with the BS DTX.  The other method of triggering BS DTX is that the UE first coordinates the UEs’ C-DRX and once the UEs’ sleep periods (C-DRX patterns) are aligned, then, the BS applies DTX. |
| Apple | Note (18): in fact we do not quite understand what this sentence means exactly and how it is different from the 1st sub-bullet. E.g. how is “DTX/DRX patterns that are defined by the BS” different from “DTX/DRX cycle configuration/patter at the gNB”?  Note (19): agree that clarification is needed |
| CATT | We are generally OK with the descriptions as the placeholder with potential revision once the results and the detailed procedures are available.  Although gNB DTX could be achieved by gNB implementation when UEs are in DRX OFF, the UE behaviors of in preparation of PDCCH monitoring and RRM/RLM measurements during DRX OFF would be impacted by gNB implementation since these behaviors are the choice of UE implementation. The gNB DTX configuration by specification would provide the clear UE behavior of measurements for preparation of PDCCH monitoring and RRM/RLM measurements only within the DTX ON period. |
| InterDigital | On note (18): Based on RAN2 agreement, the following can be added for clarification:  "Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration."  In the first sub-bullet, we also suggest changing "idle mode" to "idle/inactive mode", as indicated by Samsung |
| Ericsson1 | Our suggested updates are as follows:   * + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle mode can potentially provide longer inactivity periods at the gNB.     - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.     - cell-specific DTX/DRX operation may be different between Idle mode and connected mode   + An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS. (18)   + The ~~two~~ techniques/approaches of DTX/DRX alignment can be complementary to each other .   + [Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time such as SSB or SIB.](19)   + Reduction of periodically transmitted/semi-static configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time).(19)   + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication which can potentially provide longer inactivity periods at the gNB.   + This may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced command MAC CE and long DRX commend MAC CE. |
| OPPO | Similar as the association relationship between UE WUS and UE DRX cycle, we think the WUS for gNB can be associated with the BS DTX/DRX cycle to help wake up gNB when data arrives at UE side. We propose to add the following sub-bullet:   * + This may include association between WUS for gNB and the cell-specific DTX/DRX. |

#### Proposal #2-5

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-5: Adaptation of BS inactive state (20)
  + gNB entering into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration.
    - This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
    - This may include group common signaling for the indication of adapted active/inactive state

Notes from the moderator on above:

* Note (20) Need to Clarify (enough to be able to be evaluated by companies)
  + This is generally true while it may be possible to consider to use this as signaling aspect for previous techniques, otherwise it is unclear what to implement as a technique to achieve BS energy saving. For example, solely with a signaling to tell UE that BS is to go to sleep, the “indication” itself does not provide BS energy saving. If it is associated with BS behavior, such as sleeping, or DTX, then it seems the same as Technique#A-4.

#### Company Comments on Proposal #2-5

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| Company | Comments |
| CMCC | Share similar view as the FL.  This can also be a sub-bullet of Technique #A-4: Adaptation of DTX/DRX, if the definition of DTX/DRX is general that gNB enter a inactive duration. |
| Lenovo | For Rel-18, can define BS idle/inactive mode, where the BS transmits only SSBs, minimum system information (e.g. SIB1 or simplified SIB1), and/or paging. |
| vivo | Agree with moderator that the difference with technique#A-4 should be clarified. |
| Nokia/NSB | We share the similar view as FL and CMCC. Unless this term of BS inactive state means something different than “network DRX/DRX”, our understanding is that this technique A#5 should be merged with A#4. |
| LG Electronics | Note (20): As we commented above, Technique#A-5 can be combined with Technique#A-2. |
| ZTE, Sanechips | Similar views with FL and CMCC. We think all of techniques #A-1, #A-2 and #A-4 can provide longer inactivity periods at gNB side. The current A-5 is more like a signaling consideration. |
| Fujitsu | We share the similar view as FL and some companies that this technique can be merged with Technique #A-4. |
| Samsung | * UE behaviour should be further clarified under sleep mode. The follow two options can be considered   + Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;   + Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel * Note 20: it can work together with other techniques, e.g., #A-1, A-2, and A-4.   We suggest the following update highlight yellow. Proposal #2-5  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #A-5: Adaptation of BS inactive state (20)   + gNB entering into sleep mode for a period of time along with the indication of active/inactive state, ~~e.g., in terms of start time and duration~~.     - The indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.     - The indication may include monitoring occasion for the next BS state indication.     - This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.     - This may include group common signaling for the indication of adapted active/inactive state     - If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel. |
| CEWiT | For Note (20), The proposal #2-5 can be a separate technique to adapt the inactive state in an irregular manner based on load, UE arrival rate etc. Whereas the DTX/DRX previous technique is an adaptation based on a cycle or pattern. |
| QCOM1 | Agreement with the note. This technique can be incorporated into Technique #A-4. |
| Apple | We also wonder if “inactive state” means the same or similar to DTX/DRX in Technique #A-4 |
| CATT | We share the view with FL that this should be included in A-4. |
| InterDigital | We do not think Technique #A-5 is limited to DTX/DRX, as RAN2 is studying other related use cases as well (such as cell reselection, mobility, etc.). We think #A-5 should not be merged with #A-4, and it is better to leave #A-5 as separate for now. |
| Ericsson1 | Our suggested updates are as follows:   * + gNB entering into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration.     - This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.     - This may include UE-specific signaling, group common signaling for the indication of adapted active/inactive state |
| Rakuten | We believe such an indication should be supported so that UEs do not unnecessarily stay in active mode. We think it is beneficial to keep it a separate technique, e.g., agree with CEWIT. |

### Summary of 1st Round Discussions

Based on feedback received moderator has updated the proposals as follows. Moderator suggest using the updated proposal for further discussions.

Notation of change marks above:

* Red Underline or ~~Stikethrough~~ Text: Updated text based on comments.
* Blue Underline Text: Updated text based on comments. However, moderator thinks further clarification is needed
* Green Text: Unchanged text. However, based on comments, moderator thinks further clarification is needed.

Proposal #2-1A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-1a Adaptation of common signals and channels
  + ~~Dynamically~~~~(1)~~ ~~vary~~ Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication. The following options are various methods of adaptation.
    - Option 1) ~~This also includes~~ introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH,
    - Option 2) Different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH
    - Option 3) Transmission ~~where for some periodicity~~ occasion of one or more common signals/channels of specific periods can be skipped. (2)
    - ~~This is mainly for BS idle/inactive mode~~~~(3)~~~~, e.g. cell deactivation without DL data transmission~~.
    - Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, ~~more than one~~~~(4)~~ ~~periodicity~~ are expected to potentially provide longer inactivity periods for the gNB.
    - Option 5) Support of configuration of longer periodicity (than what is currently supported) of common signals and/or uplink random access opportunities
    - Option 6) The varying periodicity and/or dynamically changing a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.
    - Option 7) Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly ROs can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.
    - Option 8) Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.
  + Potential specification impact:
    - Since the reduction ~~Dynamic adaptation of the periodicity of~~ common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.
* Technique #A-1b Adaptation of common signals and channels
  + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB. SSB/SIB-less operations may also enable long periods of inactivity at the gNB. The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:
    - Option 1) ~~This may include~~ DL signals~~/channels~~~~(5)~~ to aid initial access and discovery of cells in lieu of SSBs.
    - Option 2) ~~This may include~~ mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.
    - ~~This technique utilizes carrier aggregation mechanism and it should be noted that use of CA means the technique is only applicable to UEs in connected mode~~~~(6)~~
    - Option 3) ~~This may include~~ cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.
    - Option 4) offloading SIB of the SIB-less cell to another cell. The SSB-less operation is used for inter-band CA case and SIB-less operation is for non-CA case
  + Potential specification impact:
    - FFS
* Technique #A-1c Adaptation of common signals and channels
  + Adaptation of search space and CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB. The following options are various methods of adaptation:
    - Option 1) ~~This may include~~ support of a long period (rather than the period as the same as the SSB period) of search space ~~CORESET 0~~(7)
    - Option 2) ~~This may include~~ support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead(8)
  + Potential specification impact:
    - FFS
  + ~~Dynamic adaptation of the periodicity of common channel/signals might have impact to the UE normal access to the network, such as initial access, and legacy UE network access.~~

Proposal #2-2A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.
    - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
    - ~~This may include report of~~ UE assistance information report may, ~~e.g., UE buffer status to~~ help gNB make decisions.
    - Reduction of time occasions or synchronization of UE specific signal/channels can be performed based on following options:
      * Option 1) RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
      * Option 2) group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals
  + gNB may enter into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration.
  + ~~Support of enhancements to synchronize the UE specific signal and channel transmission reception such that they provide longer inactivity periods at the gNB can be considered.~~
  + ~~Support reducing configuration signaling of the UE specific signals and channel transmission and reception to be reduced, e.g. by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.~~
  + Potential specification impact:
    - FFS
  + ~~The impact to the UE performance by adaptation of UE specific signal/channels should be included along with the network energy saving performance results.~~

Proposal #2-3A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS) ~~for gNB~~
  + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE~~/neighboring gNB~~ including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).
    - ~~Whether UE detection of a dormant power state/energy saving state is required before WUS transmission should be identified.~~
    - ~~Resource reserved for WUS and the assumption of the gNB receiver should be identified~~
    - ~~This may include~~ support of assistance information from the UEs intended to aid wake up operations by the gNBs.
    - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.
    - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - Wake up signal (WUS) is triggerd by MAC layer.
    - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
  + ~~This is mainly for connected mode UEs~~ Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.
  + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.
  + The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.
  + Potential specification impact:
    - FFS

Proposal #2-4A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, then the power consumption can be reduced.
  + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time or reduce periodically or semi-static transmitted/received configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time and within gNB’s DRX/DTX period)
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the BS.
    - Joint or separate configuration of DTX and DRX mode at the gNB is considered.
    - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.
    - cell-specific DTX/DRX operation may be different between Idle mode and connected mode
    - This may include association between WUS for gNB and the cell-specific DTX/DRX
  + ~~An alternative BS DTX with UE C-DRX alignment would be the use of DTX/DRX patterns that are defined by the BS.~~
  + ~~The techniques/approaches of DTX/DRX alignment can be complementary to each other .~~
  + ~~[Reducing gNB’s activities (e.g. SSB, CG PUSCH, etc.) outside UE DRX active time such as SSB or SIB.]~~
  + ~~Reduction of periodically transmitted/semi-static configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time).~~~~(19)~~
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication ~~which can potentially provide longer inactivity periods at the gNB.~~
  + This may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced ~~command~~ MAC CE and long DRX commend MAC CE.
  + Potential specification impact:
    - FFS

Proposal #2-5A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-5: Adaptation of BS inactive state
  + gNB entering into sleep mode for a period of time along with the indication of active/inactive state~~, e.g., in terms of start time and duration~~.
    - The indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.
      * Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;
      * Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel
    - The indication may include monitoring occasion for the next BS state indication.
    - This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
    - This may include group common signaling for the indication of adapted active/inactive state
    - If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.
  + Potential specification impact:
    - FFS

The following are clean versions of the Proposals.

#### Proposal #2-1A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-1a Adaptation of common signals and channels
  + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication. The following options are various methods of adaptation.
    - Option 1) introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH,
    - Option 2) Different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH
    - Option 3) Transmission occasion of one or more common signals/channels of specific periods can be skipped.
    - Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB.
    - Option 5) Support of configuration of longer periodicity (than what is currently supported) of common signals and/or uplink random access opportunities
    - Option 6) The varying periodicity and/or dynamically changing a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.
    - Option 7) Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly ROs can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.
    - Option 8) Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.
  + Potential specification impact:
    - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.
* Technique #A-1b Adaptation of common signals and channels
  + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB. SSB/SIB-less operations may also enable long periods of inactivity at the gNB. The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:
    - Option 1) DL signals to aid initial access and discovery of cells in lieu of SSBs.
    - Option 2) mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.
    - Option 3) cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.
    - Option 4) offloading SIB of the SIB-less cell to another cell. The SSB-less operation is used for inter-band CA case and SIB-less operation is for non-CA case
  + Potential specification impact:
    - FFS
* Technique #A-1c Adaptation of common signals and channels
  + Adaptation of search space and CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB. The following options are various methods of adaptation:
    - Option 1) support of a long period (rather than the period as the same as the SSB period) of search space
    - Option 2) support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead
  + Potential specification impact:
    - FFS

#### Proposal #2-2A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.
    - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
    - UE assistance information report may help gNB make decisions.
    - Reduction of time occasions or synchronization of UE specific signal/channels can be performed based on following options:
      * Option 1) RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
      * Option 2) group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals
  + gNB may enter into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration.
  + Potential specification impact:
    - FFS

#### Proposal #2-3A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)
  + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).
    - support of assistance information from the UEs intended to aid wake up operations by the gNBs.
    - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.
    - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - Wake up signal (WUS) is triggerd by MAC layer.
    - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
  + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.
  + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.
  + The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.
  + Potential specification impact:
    - FFS

#### Proposal #2-4A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, then the power consumption can be reduced.
  + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time or reduce periodically or semi-static transmitted/received configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time and within gNB’s DRX/DTX period)
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the BS.
    - Joint or separate configuration of DTX and DRX mode at the gNB is considered.
    - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.
    - cell-specific DTX/DRX operation may be different between Idle mode and connected mode
    - This may include association between WUS for gNB and the cell-specific DTX/DRX
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication
  + This may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced MAC CE and long DRX commend MAC CE.
  + Potential specification impact:
    - FFS

#### Proposal #2-5A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #A-5: Adaptation of BS inactive state
  + gNB entering into sleep mode for a period of time along with the indication of active/inactive state.
    - The indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.
      * Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;
      * Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel
    - The indication may include monitoring occasion for the next BS state indication.
    - This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
    - This may include group common signaling for the indication of adapted active/inactive state
    - If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.
  + Potential specification impact:
    - FFS

### Summary of GTW Session on Oct 12

**Focus on the following for RAN1#110bis-e**

* High level description of potential techniques for TR
* Detailed description of potential techniques for company simulations (does not necessarily need to be RAN1 agreement)
* Critical aspects that need substantial work in other WGs

### [CLOSED] 2nd Round Discussions

Based on discussion from GTW, we should split the discussion into two components. First aspect is regarding high level descriptions of the potential techniques, their potential specification impact, any impact to legacy UEs. The second aspect is providing even further details targeting providing information for evaluations.

#### Proposal #2-1B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-1a Adaptation of common signals and channels
  + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-1a Adaptation of common signals and channels
  + The following options are various methods of adaptation for Technique #A-1a.
    - Option 1) introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH,
    - Option 2) Different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH
    - Option 3) Transmission occasion of one or more common signals/channels of specific periods can be skipped.
    - Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, more than one(4) periodicity are expected to potentially provide longer inactivity periods for the gNB.
    - Option 5) Support of configuration of longer periodicity (than what is currently supported) of common signals and/or uplink random access opportunities
    - Option 6) The varying periodicity and/or dynamically changing a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.
    - Option 7) Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly ROs can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.
    - Option 8) Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.

#### Company Comments on Proposal #2-1B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | We would suggest to refine potential specification impact, as follows:   * + Potential specification impact:     - Adaptation of common signals and channels might have impact to the behavior of legacy UEs for network access, such as initial access, measurements, RRM, mobility, and so on.     - Mechanism on how UE can be informed about adaptation of common signals and channels |
| Spreadtrum | Fine for LG version, but “potential specification impact” may not only include “legacy UE”   * + Potential specification impact:     - Adaptation of common signals and channels might have impact to the behavior of UEs for network access, such as initial access, measurements, RRM, mobility, and so on.     - Mechanism on how UE can be informed about adaptation of common signals and channels   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - The legacy UEs may not operate in the cell with this technique. |
| vivo | We agree with LGE to add mechanism on how UE can be informed about adaptation of common signals and channels to potential specification impact. However, the impact to legacy UE should not be included here. So our suggestion is as follows:   * + Potential specification impact:     - Mechanism on how UE can be informed about adaptation of common signals and channels     - UE behavior for network access, such as initial access, measurements, RRM, mobility, when informed about adaptation of common signals and channels.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - This might have impact on legacy UE’s initial access |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We are OK with most of the proposals. The “potential assistance of DL indication” is not clear and could be removed. We have the following suggestion in “Purple”.  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-1a Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities~~, with potential assistance of DL indication.~~   + Background:     - [To be filled]   + Potential specification impact:     - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - ~~[To be filled]~~ The UE assumptions on the measurements on the SSB by legacy UE for initial access, RLM, and RRM for mobility.     - The potential UE transitions to out-of-sync state when the periodicity of SSB is longer than the minimum duration in RAN4, e.g., 160 ms.   + Potential impact to other WGS     - ~~[To be filled]~~ The higher layer configuration of the common control and broadcast signals and the UL resource for RACH     - The UE network access performance requirements and latency caused by adaptation of common control and broadcast channels. |
| QCOM2 | Splitting the different flavors of adaptation of common channels into two groups is a good first step. With regards to the 2nd part of the description of technique #A-1a, options 2-8 should be placed in the first part of technique #A-1a description. Since, these Options 2-8 refer to adaptation of common channels, either dynamic, or semi-static or per TCI state. If the wish is to separate these techniques, then, maybe another group of #A-1a techniques has to be drafted.  [Moderator: any suggestions on what the new technique needs to describe? Option 2 to 8 are quite of bit of different variations of adaptation. As discussed during GTW, it was suggested to not mix detailed aspects with the general description]  All of these techniques, have an impact onto RAN 2 specifications and eventually onto RAN 3 specifications, since eventually the common channels patterns have to be exchanged to neighbor gNBs. In addition, all of these techniques have an impact on UEs in idle mode and onto legacy UEs. |
| Ericsson2 | Suggest below updates (in red) for #A-1a.  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-1a Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication.   + Background:     - [To be filled]   + Potential specification impact:     - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.     - For adapting periodicity/availability of uplink random access opportunities, specification impact includes provisioning of adaptable RACH opportunities for Rel-18 UEs and associated RACH procedure.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]     - For adapting periodicity/availability of uplink random access opportunities, there is no impact to legacy UEs   + Potential impact to other WGS     - [To be filled]     - For adapting periodicity/availability of uplink random access opportunities, RACH-related procedure updates may have RAN2 impact.   For the “Additional description intended to aid evaluations (not part of agreement)”, we suggest adding the following option 5a).  Option 5a) Provisioning of additional uplink random access opportunities for Rel-18 UEs. |
| Lenovo | In our understanding, legacy UE behavior does not and cannot change due to Rel-18 adaptation of common signals and channels. Thus, there is no spec impact to the legacy UE. Potential impact on legacy UE’s cell detection, RRM/RLM measurements, and random access can be minimized by gNB employing adaptation properly. Thus, we suggest the following modification:   * + Background:     - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs.   + Potential specification impact:     - ~~Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.~~     - DL indication mechanisms to inform UE of adaptation of common signals and channels   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - Legacy UE’s behavior for cell detection, RRM and RLM measurements, and random access do not change. Network implementation may avoid potential impact on legacy UEs by employing adaptation properly. |
| DOCOMO | Regarding potential specification impact and additional considerations/aspects, we are fine with the modified version by LGE. We also think there is no spec impact on the legacy UEs since legacy UE behavior should not be changed by techniques introduced in Rel-18.  For potential impact to other WGs, higher layer configuration of the common control and broadcast signals and the UL resource for RACH can be considered as CATT proposes. |
| Intel | Suggest following revision to first bullet   * + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities, with potential assistance of DL indication.   Support Spreadtrum revision on the sections on specification impact and additional aspects.  “with potential assistance of DL indication” could use further clarification.  For impact to other WGs, the following should be added   * Impact to TTI of system information blocks in RAN2 is expected if longer periodicities of SSB or SIB1 are to be supported. * Impact to paging occasion and paging frame definition in RAN2 is expected if enhancements to paging are to be supported. |
| Apple | For potential spec impact, we support vivo’s modification.   * + Additional considerations/aspects (including any impact to legacy UEs, if any):     - This will impact the legacy UE’s performance related to cell detection, initial access, RRM and RLM measurement, and mobility.   + Potential impact to other WGS     - RAN4[/RAN2]: RRM/RLM measurement procedures |
| Samsung | Fine with the proposal |
| CMCC | We think current sentence under Potential specification impact is about potential performance impacts.  And for the specification impacts, when adaptation of common signals and channels is introduced, the potential specification impacts will include how to adapt the transmission, for example:   * Adapting the repetition periods of common channels/signals with explicit or implicit indication; * On-demand adapting of common channels/signals, including the triggering signaling design, and the triggering procedure.(this is discussed separately in proposal#2-6) * Technique #A-1a Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication.   + Background:     - [To be filled]   + Potential specification impact:     - ~~Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.~~(move to additional considerations/aspects)     - Adapting the repetition periods of common channels/signals with explicit or implicit indication;   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]     - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.   + Potential impact to other WGS     - [To be filled] |
| Fraunhofer | We agree with Spreatrum that NES techniques affect UE performance in general (including UEs complying with NES techniques specification), not only the legacy UEs. We also (agreeing with other companies) think that the impact on legacy UEs should not be noted under ‘potential specification impact’.  For ‘Description to be expected to be captured into TR (if technique is agreeable to be captured)’, the following edits are proposed:   * Technique #A-1a Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication.   + Background:     - Transmission of common signal and channels less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission is one promising way to get the benefits.   + Potential specification impact:     - Adaptation common signals and channels, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and and so on.     - Enabling UEs to adapt to the varying periodicity or transmission pattern of the common signals or channels; e.g., specification enabling UEs to enhance initial access performance to counter the impact due to increased SSBs/SIB1 periodicity   + Additional considerations/aspects (including any impact to legacy UEs):     - Impact on legacy UE: legacy UEs may not recognize the adaptation of common signal and channel; e.g., initial access of legacy UEs expecting 20 ms SSB periodicity might fail with an increased SSB periodicity.   + Potential impact to other WGS     - [To be filled]   For ‘Additional description intended to aid evaluations (not part of agreement)’, we propose the following additional option to be included:   * + - Option 9) Simplified DL signals in lieu of SSBs or prior to SSBs to improve the initial access performance significantly while letting the periodicity of transmission be large enough for NES, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions. |
| OPPO | We think adaptation of common signals and channels should not have impacts on legacy UE. We propose the following update:   * + Additional considerations/aspects (including any impact to legacy Ues, if any):     - [To be filled]     - It may have impacts on initial access performance for legacy UE.     - Legacy UE behavior is not expected to be changed. |
| CEWiT | We suggest following bullets to be further added in the potential specification impact   * + Potential specification impact:     - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.     - DL indication mechanisms to inform UE about adaptation of common signals and channels     - Adaptation of SSB structure (e.g. simplified SSB)     - Mechanism for UE to Measure and report using adapted common signals and channels.   and for the Additional description intended to aid evaluations (not part of agreement), some of the information from PBCH may also be needed to be given for initial access or for transmission of UL trigger, which cannot be avoided and hence we suggest following updates for option 1  Option 1) introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH or PSS and SSS with partial PBCH. |
| Fujitsu | We are fine with the FL’s proposal.  For potential impact to other WGs, we support CATT’s and Apple’s proposals. Impact to higher layer configuration and RLM/RRM related procedures should be discussed. |
| ZTE, Sanechips | For the following technique description, “with potential assistance of DL indication” can be moved into spec impact.   * Technique #A-1a Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities~~, with potential assistance of DL indication~~.   The following spec impact should be additional considerations.   * + Potential specification impact:     - ~~Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.~~     - Mechanisms to indicate/trigger the adaptation of the periodicity and/or a transmission pattern of downlink common and broadcast signals, including assistance of DL indication from network, UL WUS sent from UE     - Impact on UL RO   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access. |
| MediaTek | * Technique #A-1a Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication.   + Background:     - NR has provided flexible configuration for downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell. For Technique #A-1a, the intention is to evaluate and identify whether/how additional adaption design can provide useful gain for network energy saving.   + Potential specification impact:     - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access. There is need to relax UE requirements to accommodate longer access or failure report latency, lower measurement accuracy and higher handover failure rate, due to the reduced availability of common channel/signals.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - Cell measurement is related to SSB periodicity. If legacy UE cannot be indicated the change of serving/neighbor cell SSB periodicity (due to new adaptation mechanism), there is impact to measurement accuracy (if UE cannot detect the correct periodicity) or longer latency for measurement outcome or hand-over, which can cause mobility performance degradation to legacy UE.     - Legacy UE determine paging/cell common PDCCH occasions based on SIB1 configuration. If a new adaptation mechanism **other than** SI update mechanism is introduced, it is possible legacy UE cannot be notified of the change, and PO and common PDCCH monitoring will be failed.   + Potential impact to other WGS     - RAN2: Additional configuration(s) for adapting common channels/signals for a group of UE or the whole cell   Regarding the evaluations,   * The simulation/analysis should include all common channels/signals, and, according to current BS power consumption model, the BS cannot enter any sleep model, whenever there is active DL or active UL. * If SSB setting is changed, mobility performance, including hand-over failure rate, should be evaluated for identifying the potential impact to legacy UEs and network KPI(s). |
| InterDigital | We suggest capturing the following under Proposal #2-1B:   * Additional considerations/aspects (including any impact to legacy UEs, if any):   + Legacy UE may incur longer access delays or unable to perform initial access in the cell when SSBs and SI are not broadcast as expected. * Potential impact to other WGS   + RAN2 to consider impacts on the initial access procedure when the cell uses different periodicity of downlink common and broadcast signals |
| Nokia/NSB | Regarding the term skipped, we have similar concerns as some of the other companies in the sense that we are not clear whether it is the gNB behavior to skip the transmissions or whether it is UE behavior to skip the reception. This needs to be clarified in our view.  There is also a minor correction for Technique #A-1a, option 4):   Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, more than one~~(4)~~ periodicity are expected to potentially provide longer inactivity periods for the gNB. |

#### Proposal #2-6

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-1b Adaptation of common signals and channels
  + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB. SSB/SIB-less operations may also enable long periods of inactivity at the gNB.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-1b Adaptation of common signals and channels
  + The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:
    - Option 1) DL signals to aid initial access and discovery of cells in lieu of SSBs.
    - Option 2) mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.
    - Option 3) cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.
    - Option 4) offloading SIB of the SIB-less cell to another cell. The SSB-less operation is used for inter-band CA case and SIB-less operation is for non-CA case

#### Company Comments on Proposal #2-6

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | The title of Tech #A-1b and description needs to be revised. Also, we provided potential specification impact.   * Technique #A-1b On-demand SSB/SIB1 transmission   + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.   + Potential specification impact:     - On-demand SSB/SIB1 transmission or SSB/SIB1-less operation might have impact to the behavior of legacy UEs for network access, such as initial access, measurements, RRM, mobility, and so on.     - Mechanism on how UE can be informed about UL resource for on-demand SSB/SIB1 request |
| Spreadtrum | We think on-demand SSB/SIB1 also include the SSB/SIB1 configured by the cell for the active BWP in connected mode, e.g. NCD-SSB like. On-demand SSB/SIB1 is not equivalent to SSB/SIB1-less. We prefer the original version of FL. |
| vivo | We agree with LGE’s modification. Similarly, we think the impact to legacy UE should not be included in potential specification impact part. So we suggest the following update on top of LGE’s version in red:   * Technique #A-1b On-demand SSB/SIB1 transmission   + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request from UE.   + Potential specification impact:     - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request     - Conditions on how UE sends on-demand SSB/SIB1 request     - UE behavior/assumption after UE sends on-demand SSB/SIB1 request   For additional description, we think option 3 and option 4 can move to frequency domain technique. |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We are OK with the proposals with the following suggestion in purple   * Technique #A-1b Adaptation of common signals and channels   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving by the cell ON/OFF . SSB/SIB-less operations may also enable long periods of inactivity at the gNB.   + Background:     - ~~[To be filled]~~  Cell ON/OFF in Rel-12 LTE small cell works enable the support of small cell ON/OFF. The DRX was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell.   + Potential specification impact:     - ~~[To be filled]~~ The UE assumptions and behavior of SSBs/SSB1 transmission for on-demand or no transmission of SSBs/SIB1 need to be specified   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - ~~[To be filled]~~ The potent impact of RRM/RLM measurements and network access delay by legacy UEs.   + Potential impact to other WGS     - ~~[To be filled]~~ The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 of SSB-less operation. |
| DOCOMO | Regarding potential specification impact and additional considerations/aspects, we are generally fine with the CATT’s proposal. However, the potential impact may affect Rel-18 UE as well. Therefore, we propose the following update in green based on CATT’s version:   * + Potential specification impact:     - ~~[To be filled]~~ The UE assumptions and behavior of SSBs/SSB1 transmission for on-demand or no transmission of SSBs/SIB1 need to be specified   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - ~~[To be filled]~~ The potential impact of RRM/RLM measurements and network access delay by ~~legacy~~ UEs. |
| Intel | Support FL version for main bullet. Suggest to revise spec impact as follows:   * + Potential specification impact:     - On-demand SSB/SIB1 transmission or SSB/SIB1-less operation might have impact to the behavior of UEs for network access, such as initial access, measurements, RRM, mobility, and so on.     - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request     - Conditions and procedures on how UE sends on-demand SSB/SIB1 request     - UE behavior/assumption after UE sends on-demand SSB/SIB1 request   For impact to other WGs, the following should be added   * RAN4 input on feasibility of only on-demand SSB transmission for time/frequency synchronization may be needed. * RAN4 input on impact to RLM and RRM measurements from on-demand transmission of SSB may be needed. * Impact to handling of transmissions of SIB1 in RAN2 is expected if changes to SIB1 transmission cycle is changed. |
| Apple | We are generally fine with the edits above, but for impact to other WGs, we may add:   * + Potential impact to other WGS     - RAN4/RAN2: RRM/RLM measurement procedure |
| Samsung | Suggest as following:   * Technique #A-1b Adaptation of common signals and channels   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB. ~~SSB/SIB-less operations may also enable long periods of inactivity at the gNB.~~   + Background:     - [To be filled]   + Potential specification impact:     - ~~[To be filled]~~ Conditions for triggering the request   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - ~~[To be filled]~~ RAN2 |
| CMCC | In fact, we think on demand SSB/SIB1 is one specification impact of adaption of common signals/channels. And we are also OK to discuss them separately.  Here for proposal 2-6, we talk about two techniques,   * One is on demand SSB/SIB1, which means SSB/SIB1 is in fact needed for the cell, and when UEs has less requirement for the SSB/SIB1, gNB goes to a state with reduced SSB/SIB1, however, UE can trigger normal SSB/SIB1 in case there are needed.   + For this one, the specification impacts includes, details of on-demand triggering, including the triggering signaling design, triggering signalling configuration, and the triggering procedure. * The other one is SSB/SIB-less, which means the carrier is without SSB/SIB1, UE can get sync and system information from other carriers for such carrier.   **This does not mean the UE has CA capability.** As as we explained in the first round. When SSB/SIB1-less operations is introduced for some carriers, according to current specification, such carriers can not be used for initial access, which may cause initial access congestion. To solve such problems when keeping the power saving benefit of SSB/SIB1-less, enhancement can be made for UE to access such carrier with assistance information(SSB/SIB1) from other carriers.  In practical, a gNB can have multiple carriers, while the UEs it serves can work at a single carrier or multiple carriers mode. To realize power saving of gNB on one carrier, if one carrier B can share synchronization from the other carrier A, then SIB1 less or even SSB less can be applied to carrier B, regardless of whether it is Scell of one CA UE or the serving cell of other UEs without CA capability. For UEs served by such carrier B, they can finish cell search on carrier A, and initiate RACH on carrier B, if they can get associate system information from carrier A. For such carriers, UE needs assistance information from other carriers to work with such carrier.  So the potential specification impacts of SSB/SIB-less is   * + Cross carrier synchronization for single carrier operation   + System information enhancement to provide other carriers’ information and carrier selection principles for UE   Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-1b Adaptation of common signals and channels   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB. SSB/SIB-less operations may also enable long periods of inactivity at the gNB.   + Background:     - [To be filled]     - On-demand SSBs/SIB1 transmissions: SSB/SIB1 is in fact needed for the cell, and when UEs has less requirement for the SSB/SIB1, gNB goes to a state with reduced SSB/SIB1. UE can trigger normal SSB/SIB1 in case there are needed.     - SSB/SIB-less: The carrier is deployed without SSB/SIB1, UE can get sync and system information from other carriers for such carrier.   + Potential specification impact:     - [To be filled]     - Details of on-demand triggering, including the triggering signaling design, triggering signaling configuration, and the triggering procedure.     - Cross carrier synchronization for single carrier operation     - System information enhancement to provide other carriers’ information and carrier selection principles for UE   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - [To be filled]     - Cross carrier synchronization for single carrier operation may have RAN3 impact, and the system information enhancement to provide other carriers’ information and carrier selection principles for UE has RAN2 impacts. |
| Fraunhofer | Again, we suggest to note that the impact on legacy UEs only under ‘additional considerations’ as ‘potential specification impact’ should refer to R18-UEs.  For ‘Description to be expected to be captured into TR (if technique is agreeable to be captured)’, the following edits are proposed:   * Technique #A-1b Adaptation of common signals and channels   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB.   + Background:     - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 and SSB-less operations are promising way to get the benefits.   + Potential specification impact:     - Reduced or no availability of SSBs/SIB1 would result in performance degradation in terms of UE normal access to the network, such as initial access, measurements, RRM, mobility and so on.   + Specification enabling UEs capable of performing initial access with on-demand SSBs/SIB1 transmission, e.g., defining simplified DL signals preceding a UE trigger to aid initial access and discovery of cells in lieu of regular SSBsAdditional considerations/aspects (including any impact to legacy UEs, if any):     - Impact on legacy UEs: legacy UEs might not recognize such a technique   + Potential impact to other WGS     - [To be filled]   For ‘Additional description intended to aid evaluations (not part of agreement)’, we propose the following additional option to be included:   * + - Option 5) Simplified DL signals in lieu of SSBs providing necessary synchronization prior to the UE trigger for on-demand SSBs/SIB1 and potentially enhancing initial access performance altogether significantly, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions. |
| CEWiT | We suggest following updates for potential specification impacts:   * + Potential specification impact:     - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request     - DL signaling mechanism that enable UE to synchronize with the gNB for sending the on demand SSB/SIB1 request     - UE behavior/assumption after UE sends on-demand SSB/SIB1 request |
| Huawei, HiSilicon | @ VIVO and LG: on-demand SSB/SIB is not equivalent to SSB/SIB-less operation. As in option 4, UE on SIB-less carrier can obtain SIB from other carrier without transmission of UL trigger signal.  @CATT: In SSB/SIB-less cell or on-demand SSB/SIB cell, no transmission of SSB doesn’t necessarily mean cell off. So, we don’t think cell on/off should be included in this proposal.  Please find our suggestion for the part need to be filled:  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-1b Adaptation of common signals and channels   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB. SSB/SIB-less operations may also enable long periods of inactivity at the gNB.   + Background:     - [To be filled]   + Potential specification impact:     - ~~[To be filled]~~ For on-demand SSB/SIB, the potential specification in RAN1 may include:     - Uplink trigger signal design     - Downlink signal/channel [which is to aid initial access and discovery of cells in lieu of SSBs] design, if supported.     - SSB-less carriers operation is used for inter-band CA. Due to the fact that SSB-less carriers operation is already supported in intra-band CA, the existing procedure in RAN1 defined for intra-band case can be re-used in general.     - For SIB-less carrier, there is no obviously specification impact in RAN1.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - ~~[To be filled]~~     - For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB, therefore RAN2 should be involved to study the detailed RAN2 impact;     - Considering the SSB-less carriers operation is supported in intra-band CA by existing specification, the existing procedures defined in RAN2 specification for intra-band case can be re-used.     - For SIB-less carrier, SIB1 may need to be enhanced to carry necessary SIB information for other cell and UE cell (re)selection procedures may be impacted, therefore RAN2 should be involved to study the detailed RAN2 specification impact;]   Additional description intended to aid evaluations (not part of agreement)   * Technique #A-1b Adaptation of common signals and channels   + The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:     - Option 1) DL signals to aid initial access and discovery of cells in lieu of SSBs.     - Option 2) mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.     - Option 3) cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.     - Option 4) offloading SIB of the SIB-less cell to another cell. ~~The SSB-less operation is used for inter-band CA case and~~ SIB-less operation is for non-CA case.     - E.g., UE on SIB-less cell can obtain SIB via common channels transmitted on another cell. |
| Fujitsu | We are general fine with the proposal. Regarding addition description, we share the same view with vivo that option 3 and option 4 should be moved to Technique #B-1 in frequency domain. |
| ZTE,Sanechips | For the on-demand SSB/ SIB transmission, it doesn’t need to be coupled with SSB/SIB-less. It can be used to trigger gNB to transmit denser SSB/ SIB transmission. And the spec impacts include the triggering signaling/resource design, etc.   * Technique #A-1b Adaptation of common signals and channels   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB. SSB/SIB-less operations may also enable long periods of inactivity at the gNB.   + ..   + Potential specification impact:     - Signaling design for on-demand SSBs/SIB1 transmission indication, UE’s or network’s behavior in response to the on-demand indication, etc.     - System information enhancement to provide other cell’s information and cell selection for UE |
| InterDigital | We suggest capturing the following under Proposal #2-6:   * Additional considerations/aspects (including any impact to legacy UEs, if any):   + UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.   + Legacy UE unable camp or perform initial access on cell with long periods of inactivity   + Whether this technique is applicable to Connected, Inactive, or Idle mode * Potential impact to other WGS   + RAN2 to consider impacts on cell selection and reselection procedure, and SSB/SI acquisition from an anchor cell. |
| Nokia/NSB | We think Options 3 and 4 for Technique #A-1b has already covered as part of the description for Frequency-dmain under proposal #3-1B. We are not sure if the same techniques need to be repeated here also. |

#### Proposal #2-7

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-1c Adaptation of common signals and channels
  + Adaptation of search space and CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-1c Adaptation of common signals and channels
  + The following options are various methods of adaptation for technique #A-1c
    - Option 1) support of a long period (rather than the period as the same as the SSB period) of search space
    - Option 2) support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead

#### Company Comments on Proposal #2-7

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

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| Company | Comments |
| LG Electronics | More clarification on this technique is needed, in terms of what cannot be covered by Tech #A-1a.   * Technique #A-1a Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities, with potential assistance of DL indication.   If there is a difference between two techniques, that should be stated. |
| vivo | Agree with LGE that more clarification is needed. |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We also need clarification before the details of techniques could be described. |
| QCOM2 | “Adaptation of search space and CORESET 0 (e.g. in a separately configured CORESET) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB.” – This is more related to the UE power than the NW power.  It is up to the NW whether it should transmit PDCCH in a PDCCH monitoring occasion or not. Hence, we don’t think the proposal is needed. |
| Intel | Since we are capturing high level descriptions into TR, it is important that each technique descriptions are adequately explained. Agree with other companies that difference to 2-1B is not clear. |
| Apple | Agree with the comments above. |
| Samsung | Regarding ‘to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB’, for clarification, it doesn’t necessarily mean that gNB has to always transmit DCI for configured CORESET0 and its search space. The gNB can skip transmitting DCI, if it wants to, for monitoring occasion set by search space for CORESET 0. Thus, this adaptation is more from UE perspective to avoid/reduce unnecessary monitoring rather than from gNB perspective to avoid/reduce redundant DCI transmission.  Suggest to remove ‘to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB.’  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-1c Adaptation of common signals and channels   + Adaptation of search space and CORESET 0 (e.g. in a separately configured CORESET) ~~to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB~~.   + Background:     - [To be filled]   + Potential specification impact:     - [To be filled]   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - [To be filled] |
| CMCC | May be this is to reduce common PDCCH, and can be covered by Technique #A-1a, since it includes adapting cell common PDCCH.   * Technique #A-1a Adaptation of common signals and channels   Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities |
| CEWiT | As per moderator’s note (20) and our comment for 1st round, we suggest to include the former part of option 2 “ scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0” in main bullet to be captured in TR. Since scheduling of SIB1 using SSB will have clear specification impacts. Thus, we suggest to update the proposal as follows: Proposal #2-7 Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-1c Adaptation of common signals and channels   + Adaptation of search space and CORESET 0 (e.g. in a separately configured CORESET, scheduling SIB1 using SSB etc.) to avoid/reduce redundant DCI transmissions within the CORESET 0 for the gNB.   + Background:     - SIB1 in NR is scheduled by DCI’s in CORESET 0, the DCI transmission consumes energy at the gNB and therefore scheduling SIB1 using SSB will avoid the transmissions of DCIs.   + Potential specification impact:     - Adaptation of SSB structure to accommodate scheduling information for SIB1     - Mechanism to differentiate between legacy SSB and SSB scheduling SIB1 or mechanism for backward compatibility. |
| Huawei, HiSilicon | Agree with QC and no need for this. |
| ZTE, Sanechips | We share similar views with other companies that it can be covered by the proposal 2-1B. |

#### Proposal #2-2B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.
    - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
    - UE assistance information report may help gNB make decisions.
  + gNB may enter into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reduction of time occasions or synchronization of UE specific signal/channels can be performed based on following options:
    - Option 1) RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
    - Option 2) group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals

#### Company Comments on Proposal #2-2B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

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| Company | Comments |
| LG Electronics | “synchronizing the UE specific signal and channel transmission reception” seems unclear. Unless this part is clarified, we suggest to remove that part. In addition, we clarified what could be the difference between legacy BSR and UE assistance information here.   * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Reducing/omitting the number of time occasions for the UE specific resources during periods of low activity.     - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).     - UE assistance information reporting zero buffer status may help gNB make decisions. |
| Spreadtrum | If the periodic transmission/reception (RS etc.) is skipped by gNB, the gNB may perform DTX. Why do we have the duplicated techniques? |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We would prefer to see the impact to the performance and network energy saving gain first before we further discuss the detail of specification impact. |
| Ericsson2 | Suggest adding “UE-specific” to Option 2. |
| Intel | * + Potential specification impact:     - Configuration(s) and procedure(s) related to CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS). |
| Apple | We also feel this is somewhat related to DTX/DRX, especially with the bullet “gNB may enter into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration”. Maybe some clarification is needed to provide sufficient distinction. |
| Samsung | Suggest as following:   * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Reducing/omitting ~~the number of~~ time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.     - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).     - ~~UE assistance information report may help gNB make decisions.~~   + gNB may enter into sleep mode for a period of time along with the indication of ~~active/inactive~~ NES/non-NES state, e.g., in terms of start time and duration.   + Background:     - [To be filled]   + Potential specification impact:     - ~~[To be filled]~~ gNB indication of reducing/omitting the number of time occasions     - UE assistance information report   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - RAN2 |
| CMCC | The potential specification enhancement of reducing transmission of UE specific channels/signals includes:   * + Potential specification impact:     - [To be filled]     - Dynamic signaling design to reduce transmission of these UE specific channels/signals, by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity. |
| Fujitsu | For potential impact to other WGs, we would like to add:   * + Potential impact to other WGS     - RLM/RRM measurement procedure based on periodic CSI-RS |
| ZTE, Sanechips | The UE assistance information part doesn’t need to be included in the tech description. And gNB’s behavior doesn’t need to to be restricted, by whether to enter into inactive period.   * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.     - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).     - ~~UE assistance information report may help gNB make decisions.~~   + ~~gNB may enter into sleep mode for a period of time along with the indication of active/inactive state, e.g., in terms of start time and duration.~~ |
| InterDigital | We also suggest capturing the following under Proposal #2-2B:   * Potential specification impact:   + Configuration of UE-specific resources available in each network energy saving state and dynamic indication of a network energy saving state * Additional considerations/aspects (including any impact to legacy UEs, if any):   + Legacy UEs are not able to use resources in all network energy saving states. |

#### Proposal #2-3B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)
  + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).
  + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.
  + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)
  + Additional aspects of waking up gNB
    - Support of assistance information from the UEs intended to aid wake up operations by the gNBs.
    - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.
    - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - Wake up signal (WUS) is triggerd by MAC layer.
    - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.

#### Company Comments on Proposal #2-3B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

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| Company | Comments |
| LG Electronics | To align it with Tech #A-2, “during periods of low activity” can be used instead of “dormant power state/energy saving state”. “UEs to the gNB” is unclear to us. Regarding power model of WUS receiver, it should be discussed under 9.7.1.   * Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)   + In order to wake up gNB during periods of low activity, wake up signal (WUS) can be transmitted by the UE.   + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + Potential specification impact:     - Mechanism on how UE can be informed about WUS signal/resource     - Mechanism for UE to determine WUS transmission power   + Additional considerations/aspects (including any impact to legacy UEs, if any): |
| Spreadtrum | Confused about “dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state)”. The state of active/sleep we defined is only for evaluation purpose. The “state machine” for gNB is implementation specific. I don’t believe we can make the “state machine” of gNB clear for NES topic, which is ultimately complicated in my view.  If it means UE wake the gNB up during deep/light/micro sleep, it is fine for me. |
| vivo | In our understanding, UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment. On the other hand, there is also other understanding that UE WUS triggered by MAC layer is used mainly for connected UEs to enable semi-static UL transmissions. So, we think it is not OK to say “Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs”. This should be removed from high level description. Besides, we have the following suggestion on high level part.   * Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)   + In order to wake up gNB that is in an energy saving state, wake up signal (WUS) can be transmitted by the UE.   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + Background:     - [To be filled]   + Potential specification impact:     - WUS signal/channel design     - Mechanism on how UE can be informed about WUS configuration     - Condition on how/when UE sends WUS     - UE behavior/assumption after sending WUS   + Additional considerations/aspects (including any impact to legacy UEs, if any):   For additional description, it should be clear enough for further evaluation Per Chairman’s guidance below:   * Detailed description of potential techniques for company simulations (does not necessarily need to be RAN1 agreement)   However, each of current listed bullet is not clear enough for further evaluation. Here we provide some suggestions for detailed description based on our understanding   * Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)   + Additional aspects of waking up gNB     - Option 1: UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring (i.e., cell off/inactive period), or with sparse SSB/SIB1 transmission and RACH monitoring (e.g. 160ms) * UE may send WUS when moving to the coverage of this energy saving cell or there is need for fast access/synchronization/measurement * The WUS may trigger gNB’s normal operation, i.e. normal SSB/SIB1 transmission and RACH monitoring (e.g. 20ms) * UE reads SSB/SIB1 and perform random access if applicable after transmitting WUS   + - Option 2: UE WUS is used to wake up a gNB in an energy saving state without reception of semi-static UL transmissions * Wake up signal (WUS) is triggerd by MAC layer. * UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.   Note that option 2 is formulated by the comments from the proponent company. Please correct it if any mis-understanding. |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | The proposal of UL wakeup to the gNB in the NES state has lots of assumption. First, UE would transmit UL signals (both synchronously with TA or asynchronously. e.g., RACH) to a cell when it is synchronized with the DL of the given cell and set its UL Tx power based on the PL reference of the DL signals. Alternatively, the gNB in the NES state needs to be provided with the configuration of the UL signals (e.g., SRS for UL UE positioning) and the timing information in order for the gNb detection. The UL WUS proposal needs to clarify of all the assumptions  We have the following suggestions,   * Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)   + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell) with the assumption of UE synchronized with the gNB in the NES state or the gNB in the NES state is provided with timing information for detection of WUS.   + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.   + ~~Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.~~   + Background:     - [To be filled]   + Potential specification impact:     - ~~[To be filled]~~ UE synchronizes with both the serving cell and the gNB in the NES state.     - UE measurements of PL of the gNB in the NES state for the UL power setting of UL WUS   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.   + Potential impact to other WGS     - ~~[To be filled]~~ The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state. |
| QCOM2 | Need to separate the “Cell WUS” signal for UEs in connected mode and for UEs in “idle/inactive mode”. For example, the last two points (i.e. cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell.  In the second bullet, both DL synchronization and beam acquisition have to be obtained beforehand. This is applicable for both cases:   * UEs in idle/inactive mode * UEs in connected mode   In general, the overall design of cell WUS should consider the beam aspect.  The impact from these proposals onto RAN 2 specifications should be investigated.  Below is some suggested update to the proposal:   * Technique #A-3: Wake up of ~~energy saving~~ gNB triggered by UE wake up signal (WUS)   + A UE can send an uplink signal to transition a gNB from ~~Wake up of gNB that is in~~ a dormant power state/energy saving state ~~(e.g., SSB-less/SIB1-less/SSB relaxed state)~~ to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.~~,~~ ~~wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).~~   + ~~Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.~~   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + Potential specification impact:     - Uplink signal design & related procedure for waking up a gNB   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - ~~The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.~~     - [Qualcomm commented: This belongs to evaluation methodology.] |
| Intel | Support vivo’s update  For impact to other WGs, the following should be added   * RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is dormant may be needed. |
| Samsung | ‘including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).’ is unclear and seems not necessary.  Suggest as following:   * Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)   + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE ~~including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).~~   + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + Background:     - ~~[To be filled]~~ If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.   + Potential specification impact:     - ~~[To be filled]~~ Conditions for triggering the request, e.g., DL synchronization     - Signaling for the request     - UE behavior after transmitting the request   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.   + Potential impact to other WGS     - ~~[To be filled]~~ RAN2 |
| CMCC | Share similar view with other companies that this can be used for both idle/inactive and connected mode UEs. For waking up gNB to transmit normal common signals /channels or UE specific signals and channels, it seems the function of wake up signals and the on-demand trigger signals are similar. May be the difference can be clarified.  The specification impacts also include wake up signal configuration, signal design, and wake up procedure. |
| Fraunhofer | We agree with CATT on the potential need for synchronization and power setting prior to WUS transmission.  The following edits are proposed:  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)   + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell).   + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + Background:     - For waking up gNBs in sleep mode or energy saving sate without regular transmission of SSBs/SIB1 in the presence of UEs demanding connectivity.   + Potential specification impact:     - Specification enabling UEs to obtain necessary DL synchronization and measurements prior to the WUS in the uplink   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - The power model of receiving WUS is associated with the gNB receiver sensitivity of WUS decoding, which will reflect the results of UE WUS coverage area.     - Impact on legacy UEs: legacy UEs do not support this feature   + Potential impact to other WGS   [To be filled] |
| OPPO | We propose the following update:   * Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)   + Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state), wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell), this includes gNB informing other UEs about the dormant power state/energy saving state change after waking up.   + Usage of this technique is more applicable to connected mode UEs, but does not preclude usage on idle/inactive UEs.   + Can be used in support of techniques #A-1 techniques #A-2 techniques #A-4 and other techniques. Exact design may depend on the supported technique. |
| CEWiT | The dormant cell/gNB can be activated using WUS. The WUS can be transmitted by both UE(Connected or idle) or the neighbor gNB(e.g. anchor gNB of connected UEs), hence clarification is needed for the latter part of first bullet i.e. “wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell)” whether it means that the WUS cam also be transmitted by anchor signal based on assistance from their connected UEs.  And for Potential specification impact, we have following suggestion:   * + Potential specification impact     - Mechanism on how UE can be informed about configuration for sending WUS     - DL signalling mechanism that enable UE to synchronize with the gNB for sending WUS     - UE behavior/assumption after UE sends WUS |
| ZTE, Sanechips | We also agree that UE who sends WUS can be in RRC or idle/inactive state.  Furthermore, it doesn’t need to imply that gNB has to wake up by WUS sent from UE.  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #A-3: wake up signal (WUS) transmitted by UE to energy saving gNB   ~~Wake up of energy saving gNB triggered by UE wake up signal (WUS)~~   * + ~~Wake up of gNB that is in a dormant power state/energy saving state (e.g., SSB-less/SIB1-less/SSB relaxed state),~~ wake up signal (WUS) transmitted by the UE including UEs to the gNB (e.g. the gNB/cell in dormant state or the anchor gNB/cell, or SSB-less/SIB1-less/SSB relaxed state).   + Usage of this technique is ~~more~~ applicable to connected mode UEs, ~~but does not preclude usage on~~ idle/inactive UEs.   + Can be used in support of techniques #A-1 techniques #A-2 and other techniques. Exact design may depend on the supported technique.   + Potential specification impact:     - WUS design, including signaling format, resource.     - UE’s / network’s behavior in response to WUS |
| InterDigital | We are generally fine with Proposal #2-3B and suggest capturing the following:   * Potential specification impact:   + Design of WUS transmitted by UE   + Conditions for triggering WUS transmission |

#### Proposal #2-4B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, then the power consumption can be reduced.
  + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time or reduce periodically or semi-static transmitted/received configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time and within gNB’s DRX/DTX period)
  + Background:
    - [To be filled]
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX cycle configuration/pattern at the BS
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the BS.
    - Joint or separate configuration of DTX and DRX mode at the gNB is considered.
    - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.
    - cell-specific DTX/DRX operation may be different between Idle mode and connected mode
    - This may include association between WUS for gNB and the cell-specific DTX/DRX
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication
  + This may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced MAC CE and long DRX commend MAC CE.

#### Company Comments on Proposal #2-4B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

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| Company | Comments |
| LG Electronics | As we commented before, we believe all techniques should be described from UE perspective. In that sense, we suggest the following changes.   * Technique #A-4: Enhancement of UE DRX operation   + UE NES-DRX operation can be introduced for gNB to provide inactive opportunity. During the inactive duration, UE does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB can be expected by UE, then the gNB’s power consumption can be reduced.   + UE NES-DRX cycle configuration/pattern can be adapted such that the DRX cycle configured for UEs in connected mode or idle/inactive mode are aligned, which can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time. |
| Spreadtrum | Prefer the FL’s version. UE DRX is for UE power saving. At least so far, we do not mix the UE power saving and gNB power saving together for study purpose. In the WI, we can combine them. |
| vivo | We also prefer original FL version. There could be UE behavior change based on BS DTX/DRX configuration |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We also support the FL’s proposal over other suggested operation. |
| QCOM2 | The background of this proposal is that in case of DTX the BS can go to sleep mode, mainly light or micro sleep. The BS can temporarily switch off some parts of the BS Tx chain. Similar thinking applies for DRX, the BS can temporarily switch off some parts of the BS Rx chain.  The RAN 1 specification impact is that when the network pauses transmission, common control channels as well as CSI-RS used for either mobility or for other purposes.  Impact from BS DTX/DRX onto legacy UEs has to be assessed. Impact onto Rel. 18 idle/inactive UEs can be kept to zero if the BS performs DTX outside of SSB/SI transmission instants. The same applies when BS performs DRX outside the RO slots.  The impact of BS DTX/DRX on RAN 2 and RAN 3 specifications, in terms of BS DTX/DRX patterns definition and in terms of BS DTX/DRX patterns exchange across neighbor BSs. |
| Ericsson2 | Suggest below updates (in red).   * + Potential specification impact:     - [To be filled]     - Introduction of mechanism/signaling to enable inactive opportunity for gNB   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]     - For, introduction of mechanism/signaling to enable inactive opportunity for gNB,       * when it is done in a UE-specific manner(e.g. for connected mode Rel-18 UEs), no impact to legacy UEs.       * when it is done in a legacy UE-transparent manner(e.g. for legacy UEs in idle and/or connected mode), no impact to legacy UEs.   + Potential impact to other WGS     - [To be filled]     - Introduction of mechanism/signaling to enable inactive opportunity for gNB can have at least RAN2 impact and possibly RAN3 (up to RAN3 discussions). |
| Intel | We prefer FL version, with revisions as follows:   * + DTX/DRX cycle can be introduced so that gNB has the opportunity to be inactive. During the duration when gNB is inactive, gNB does not need to transmit or receive signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, so that the power consumption at the gNB can be reduced.   + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time or reduce periodically or semi-static transmitted/received configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time and within gNB’s DRX/DTX period)   Potential specification impact   * Configuration and indication of gNB’s DTX/DRX cycle information to UE * UE behavior/procedure when gNB’s DTX/DRX cycle is in operation   For impact to other WGs, the following should be added   * Changes to UEs DTX/DRX may require inputs from RAN2 as specification for DRX is mainly defined in RAN2 specification. * Discussion with RAN2 may be needed on which specification either RAN1 or RAN2 the gNB DTX/DRX operation will be described (if supported). |
| Apple | * + Potential specification impact:     - Signaling for indicating the DTX/DRX cycle configuration/pattern to the UE |
| CMCC | Adaptation of DTX/DRX may include two possible alternatives,  One is to align C-DRX of UE configurations, then there will be implicit duration that falls in intersection of all UE’s inactive time, then gNB can get sleep chance.  The other one is to explicitly define DTX/DRX pattern for gNB.  So similar modification as LG Electronics can be adopted, however, it is not only UE DRX enhancement.   * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, then the power consumption can be reduced.   + Enhancement of UE C-DRX ~~DTX/DRX cycle configuration/pattern at the BS~~, which can be potentially ~~aligned with~~ align the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time ~~or reduce periodically or semi-static transmitted/received configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time and within gNB’s DRX/DTX period)~~   + Background:     - [To be filled]     - Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.   + Potential specification impact:     - [To be filled]     - Defining DTX/DRX pattern for gNB.     - Mechanisms to align C-DRX configuration of UE, such as signaling design to align the C-DRX configuration.     - Mechanism to wake up gNB from DTX/DRX.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - [To be filled] |
| OPPO | We support the following change proposed by Intel:  Potential specification impact   * Configuration and indication of gNB’s DTX/DRX cycle information to UE * UE behavior/procedure when gNB’s DTX/DRX cycle is in operation |
| ZTE, Sanechips | We prefer FL’s version. Some suggestions are as below.   * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB~~, then the power consumption can be reduced~~.   + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time or reduce periodically or semi-static transmitted/received configured channels/signals(e.g. SSB, SIB, CG PUSCH, RO etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time, or ~~and~~ within gNB’s DRX/DTX period)   + Potential specification impact:     - Design of DTX/DRX pattern     - Adaptation of DTX/DRX by DL indication/WUS triggering     - Impact on periodic signal/channel transmission |
| MediaTek | DRX parameters, including cycle, on-duration and inactivitiy timers, are typically bending to service or QoS requirements. In this regard, enforcing a cell specific pattern is not feasible if three are different services demanded in a cell. From our evaluations (R1-2209501), we show it will be sufficient to align DRX offset values for the UEs in a cell. And, to minimize BS active time, the cell specific offset should be aligned o close to SS burst. By the above, we would also suggest the following revision:   * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX can be introduced for gNB to provide inactive opportunity. During the inactive duration, gNB does not need to transmit or receive periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB, then the power consumption can be reduced.   + DTX/DRX cycle configuration/pattern at the BS, which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time or reduce periodically or semi-static transmitted/received configured channels/signals(e.g. SSB, SIB, CG PUSCH etc.) during the longer inactivity periods (i.e. outside UE’s DRX active time and within gNB’s DRX/DTX period)   + If UE DRX parameters, including cycle, on-duration and inactivity timers, can not be aligned to a cell specific setting due to different QoS requirements, cell-wise alignment on DRX offset for UE DRX operation can be utilized. Alignment to cell specific RS, e.g., SSB, is also useful to maximize BS inactivity/sleep time.   + Background:     - NR UE supports DRX operation as Rel-15 mandatory feature. Since UE will not monitor channels/signals from BS when outside DRX active time, there is corresponding restriction to BS activity time.     - Alignment of UEs’ DRX active time to BS active time for common channels/signals (e.g. SSB) can be useful to minimize total BS active time. Yet, UE’s setting of DRX cycle, on-duration and inactivity timers are subject to QoS requirement of the UE’s data service, and alignment on DRX offset would be more feasible to accommodate different services and QoS requirements   + Potential specification impact:     - A set of cell-specific DRX configuration, including at least DRX offset value(s), in SIB     - A mechanism of triggering adaptation for UE to align with the indicated cell-specific DRX configuration, e.g. DRX offset value   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - N/A since if legacy UE’s DRX offset cannot be adjusted by the new adaptation mechanism, BS is expected to reconfigure UE’s DRX setting or accommodate UE’s active time durations   + Potential impact to other WGS     - RAN2: Inclusion of cell-specific DRX configuration, including at least DRX offset value(s), in SIB   Additional description intended to aid evaluations (not part of agreement)   * Technique #A-4: Adaptation of DTX/DRX   + DRX offset configuration at BS     - Offset value can be aligned with or close to SS burst location so as to minimize total BS active time for transmitting UE data and common channels/signals   + DTX/DRX cycle configuration/pattern at the BS     - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.     - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the BS.     - Joint or separate configuration of DTX and DRX mode at the gNB is considered.     - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.     - cell-specific DTX/DRX operation may be different between Idle mode and connected mode     - This may include association between WUS for gNB and the cell-specific DTX/DRX   + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication   + This may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced MAC CE and long DRX commend MAC CE. Cell-specific signaling can be based on paging PDCCH or paging early indication (DCI format 2\_7). |
| InterDigital | We suggest capturing the following under Proposal #2-4B:   * Potential specification impact:   + Configuration of DRX cycle aligned with the DTX/DRX cycle configuration/pattern used at the gNB for network energy saving   + Dynamic L1/L2 indication to UE on the DTX mode/configuration applied at gNB and/or for switching to a DRX cycle corresponding to network energy saving |

#### Proposal #2-5B

Description to be expected to be captured into TR (if technique is agreeable to be captured).

* Technique #A-5: Adaptation of BS inactive state
  + gNB entering into sleep mode for a period of time along with the indication of active/inactive state.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-5: Adaptation of BS inactive state
  + gNB sleep mode indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.
    - Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;
    - Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel
  + The indication may include monitoring occasion for the next BS state indication.
  + This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
  + This may include group common signaling for the indication of adapted active/inactive state
  + If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.

#### Company Comments on Proposal #2-5B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | Tech #A-5 seems to be quite overlapped with Tech #A-2. |
| Spreadtrum | We think “Energy-saving state” is not useful. The states in power mode are good enough and better for understanding. |
| vivo | This inactive state is quite similar with the inactive period defined in Tech#A-4. The main difference with Tech#A-4 should be clarified. |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | Technique #A5 could be the subset of Techniques #A-1B and A-4 |
| QCOM2 | From all the points above only the first one is not needed. A clarification on the last bullet  If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel to/from this gNB or only transmits/receives a particular set of signal/channel. |
| DOCOMO | This can be the subset of Tech A-4. |
| Intel | Indication of gNB entering into sleep mode/energy saving state/inactive state for a period of time Potential specification impact:   * Configuration of different sleep/inactivity duration and DL indication of selected duration * Whether any signal/channel transmission allowed in inactive duration * Associated UE behavior |
| Apple | We also think this may be merged into Tech#A-4. |
| Samsung | Support the proposal and suggest the following update.   * Technique #A-5: Adaptation of BS inactive state   + gNB entering into sleep mode for a period of time along with the indication of ~~active/inactive~~ NES/non-NES state.   + Background:     - Without knowing the gNB state, a UE may still receive DL channels and transmit UL channels resulting in unnecessary UE power consumption. In addition, the gNB may miss unknown UL signals (e.g., SR/CG PUSCH) resulting in UL performance loss.   + Potential specification impact:     - Signaling to indicate gNB NES state.     - UE behavior under gNB NES state.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - ~~[To be filled]~~ RAN2 |
| CMCC | The solutions to reduce common signals/channels transmission and reception, to reduce UE specific signals/channels, to enhance DTX/DRX, all contribute to increase gNB inactive duration and provide more sleeping chance. The additional benefit of introduce implicit inactive state need to be clarified. |
| CEWiT | As per our comment in first round of discussion, this technique deals with adaptation of sleep mode irregularly based on load, UE arrival rate etc. This does not follow any cycle or pattern as given in Tech A-4 hence it should be a separate technique. So, we are fine with the proposal #2-5B  For background, we suggest following update:  Background   * Currently gNB cannot enter into sleep mode based on various parameters like load and UE arrival rate, especially dynamic adaptation. Also, NR doesn’t support the mechanisms to deal with preconfigured operation to UE, if the gNB enters into sleep mode. An indication about irregular or abrupt adaptation of gNB entering sleep mode helps the UE to avoid unnecessary transmission/reception of signal/channel including preconfigured ones.   Potential Specification Impact   * impact on preconfigured operations at the UE such as Harq codebook, SSB etc   + UE transmit/receive by resuming the preconfigured operation upon gNB switching ON |
| Fujitsu | Agree with other companies that Technique #A-5 can be merged with Technique #A-4. |
| InterDigital | As commented previously, Technique #A-5 can be applicable to other scenarios, besides DTX/DRX, such as mobility and cell reselection. We suggest retaining Proposal #2-5B as separate and not merging with Technique #A-4  We also suggest capturing the following under Proposal #2-5B:   * Potential specification impact:   + Mechanism for indicating the network energy states in current or future time periods. * Additional considerations/aspects (including any impact to legacy UEs, if any):   + Legacy UEs may incur longer access delays or unable to access the cell in some BS inactive states. |

### Summary of 2nd Round Discussions

#### Proposal #2-1C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-1a Adaptation of common signals and channels
  + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities.
  + Background:
    - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs.Transmission of common signal and channels less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission is one promising way to get the benefits.
    - NR has provided flexible configuration for downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell. For Technique #A-1a, the intention is to evaluate and identify whether/how additional adaption design can provide useful gain for network energy saving.
  + Potential specification impact:
    - UE behavior for network access, such as initial access, measurements, RRM, and mobility, when informed about adaptation of common signals and channels. There is need to relax UE requirements to accommodate longer access or failure report latency, lower measurement accuracy and higher handover failure rate, due to the reduced availability of common channel/signals.
    - Mechanism on how UE can be informed about adaptation of common signals and channels
    - For adapting periodicity/availability of uplink random access opportunities, specification impact includes provisioning of adaptable RACH opportunities for Rel-18 UEs and associated RACH procedure.
    - DL indication mechanisms to inform UE of adaptation of common signals and channels.
    - Impact to TTI of system information blocks in RAN2 is expected if longer periodicities of SSB or SIB1 are to be supported.
    - Impact to paging occasion and paging frame definition in RAN2 is expected if enhancements to paging are to be supported.
    - Enabling UEs to adapt to the varying periodicity or transmission pattern of the common signals or channels; e.g., specification enabling UEs to enhance initial access performance to counter the impact due to increased SSBs/SIB1 periodicity.
    - Mechanisms to indicate/trigger the adaptation of the periodicity and/or a transmission pattern of downlink common and broadcast signals, including assistance of DL indication from network, UL WUS sent from UE
    - Impact on UL RO
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The legacy UEs may not operate in the cell with this technique. Legacy UEs may not recognize the adaptation of common signal and channel; e.g., initial access of legacy UEs expecting 20 ms SSB periodicity might fail with an increased SSB periodicity.
    - The UE assumptions on the measurements on the SSB by legacy UE for initial access, RLM, and RRM for mobility may get impacted.
    - The potential UE transitions to out-of-sync state when the periodicity of SSB is longer than the minimum duration in RAN4, e.g., 160 ms.
    - For adapting periodicity/availability of uplink random access opportunities, there is no impact to legacy UEs.
    - Legacy UE’s behavior for cell detection, RRM and RLM measurements, and random access do not change. Network implementation may avoid potential impact on legacy UEs by employing adaptation properly.
    - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.
    - Cell measurement is related to SSB periodicity. If legacy UE cannot be indicated the change of serving/neighbor cell SSB periodicity (due to new adaptation mechanism), there is impact to measurement accuracy (if UE cannot detect the correct periodicity) or longer latency for measurement outcome or hand-over, which can cause mobility performance degradation to legacy UE.
    - Legacy UE determine paging/cell common PDCCH occasions based on SIB1 configuration. If a new adaptation mechanism other than SI update mechanism is introduced, it is possible legacy UE cannot be notified of the change, and PO and common PDCCH monitoring will be failed.
  + Potential impact to other WGS
    - The higher layer configuration of the common control and broadcast signals and the UL resource for RACH may have RAN2 impact
    - The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.
    - Additional configuration(s) for adapting common channels/signals for a group of UE or the whole cell may impact RAN2 specification.
    - RAN2 to consider impacts on the initial access procedure when the cell uses different periodicity of downlink common and broadcast signals

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-1a Adaptation of common signals and channels
  + The following options are various methods of adaptation for Technique #A-1a.
    - Option 1) introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH, or PSS and SSS with partial PBCH
    - Option 2) Different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH
    - Option 3) Transmission occasion of one or more common signals/channels of specific periods can be skipped.
    - Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, more than one periodicity are expected to potentially provide longer inactivity periods for the gNB.
    - Option 5) Support of configuration of longer periodicity (than what is currently supported) of common signals and/or uplink random access opportunities
    - Option 5a) Provisioning of additional uplink random access opportunities for Rel-18 UEs.
    - Option 6) The varying periodicity and/or dynamically changing a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.
    - Option 7) Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly ROs can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.
    - Option 8) Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.
    - Option 9) Simplified DL signals in lieu of SSBs or prior to SSBs to improve the initial access performance significantly while letting the periodicity of transmission be large enough for NES, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.
    - Option 10) support of a long period (rather than the period as the same as the SSB period) of search space
    - Option 11) support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead

#### Proposal #2-6A

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-1b Adaptation of SSB
  + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving by the cell ON/OFF.
  + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + Background:
    - Cell ON/OFF in Rel-12 LTE small cell works enable the support of small cell ON/OFF. The DRX was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell.
    - On-demand SSBs/SIB1 transmissions: SSB/SIB1 is in fact needed for the cell, and when UEs has less requirement for the SSB/SIB1, gNB goes to a state with reduced SSB/SIB1. UE can trigger normal SSB/SIB1 in case there are needed.
    - SSB/SIB-less: The carrier is deployed without SSB/SIB1, UE can get sync and system information from other carriers for such carrier.
    - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 and SSB-less operations are promising way to get the benefits.
  + Potential specification impact:
    - On-demand SSB/SIB1 transmission or SSB/SIB1-less operation might have impact to the behavior of wUEs for network access, such as initial access, measurements, RRM, mobility, and so on.
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - Conditions and procedures on how UE sends on-demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - The UE assumptions and behavior of SSBs/SSB1 transmission for on-demand or no transmission of SSBs/SIB1 need to be specified
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Details of on-demand triggering, including the triggering signaling design, triggering signaling configuration, and the triggering procedure.
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Reduced or no availability of SSBs/SIB1 would result in performance degradation in terms of UE normal access to the network, such as initial access, measurements, RRM, mobility and so on.
    - Specification enabling UEs capable of performing initial access with on-demand SSBs/SIB1 transmission, e.g., defining simplified DL signals preceding a UE trigger to aid initial access and discovery of cells in lieu of regular SSBs
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - DL signaling mechanism that enable UE to synchronize with the gNB for sending the on demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - For on-demand SSB/SIB, the potential specification in RAN1 may include:
      * Uplink trigger signal design
      * Downlink signal/channel [which is to aid initial access and discovery of cells in lieu of SSBs] design, if supported.
      * SSB-less carriers operation is used for inter-band CA. Due to the fact that SSB-less carriers operation is already supported in intra-band CA, the existing procedure in RAN1 defined for intra-band case can be re-used in general.
      * For SIB-less carrier, there is no obviously specification impact in RAN1.
    - Signaling design for on-demand SSBs/SIB1 transmission indication, UE’s or network’s behavior in response to the on-demand indication, etc.
    - System information enhancement to provide other cell’s information and cell selection for UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The potential impact of RRM/RLM measurements and network access delay by UEs.
    - Impact on legacy UEs: legacy UEs might not recognize such a technique.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UE unable camp or perform initial access on cell with long periods of inactivity
    - Whether this technique is applicable to Connected, Inactive, or Idle mode
  + Potential impact to other WGS
    - The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 of SSB-less operationRAN4 input on feasibility of only on-demand SSB transmission for time/frequency synchronization may be needed.
    - RAN4 input on impact to RLM and RRM measurements from on-demand transmission of SSB may be needed.
    - Impact to handling of transmissions of SIB1 in RAN2 is expected if changes to SIB1 transmission cycle is changed.
    - Cross carrier synchronization for single carrier operation may have RAN3 impact, and the system information enhancement to provide other carriers’ information and carrier selection principles for UE has RAN2 impacts.
    - For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB, therefore RAN2 should be involved to study the detailed RAN2 impact;
    - Considering the SSB-less carriers operation is supported in intra-band CA by existing specification, the existing procedures defined in RAN2 specification for intra-band case can be re-used.
    - For SIB-less carrier, SIB1 may need to be enhanced to carry necessary SIB information for other cell and UE cell (re)selection procedures may be impacted, therefore RAN2 should be involved to study the detailed RAN2 specification impact;]
    - RAN2 to consider impacts on cell selection and reselection procedure, and SSB/SI acquisition from an anchor cell.

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-1b Adaptation of common signals and channels
  + The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:
    - Option 1) DL signals to aid initial access and discovery of cells in lieu of SSBs.
    - Option 2) mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.
    - [Option 3) cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.]
      * [moderator note: Repeat of #3-1B?]
    - [Option 4) offloading SIB of the SIB-less cell to another cell. and SIB-less operation is for non-CA case.]
      * E.g., UE on SIB-less cell can obtain SIB via common channels transmitted on another cell.
      * [moderator note: Repeat of #3-1B?]
    - Option 5) Simplified DL signals in lieu of SSBs providing necessary synchronization prior to the UE trigger for on-demand SSBs/SIB1 and potentially enhancing initial access performance altogether significantly, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.

LGE, vivo, CATT, Qualcomm, Intel, Huawei, and ZTE commented Technique A-1c is basically same as A-1. Suggest to not follow up with Proposal #2-7B.

#### Proposal #2-7A

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* ~~Technique #A-1c Adaptation of common signals and channels~~
  + ~~Adaptation of search space and CORESET 0 (e.g. in a separately configured CORESET).~~
  + ~~Background:~~
    - ~~[To be filled]~~
  + ~~Potential specification impact:~~
    - ~~[To be filled]~~
  + ~~Additional considerations/aspects (including any impact to legacy UEs, if any):~~
    - ~~[To be filled]~~
  + ~~Potential impact to other WGS~~
    - ~~[To be filled]~~

Additional description intended to aid evaluations (not part of agreement)

* ~~Technique #A-1c Adaptation of common signals and channels~~
  + ~~The following options are various methods of adaptation for technique #A-1c~~
    - ~~Option 1) support of a long period (rather than the period as the same as the SSB period) of search space~~
    - ~~Option 2) support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead~~

LGE, Spreadtrum, CATT, Apple commented further detailed description is needed.

#### Proposal #2-2C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.
    - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - gNB may enter into sleep mode for a period of time along with the indication of network energy saving or non enery saving state, e.g., in terms of start time and duration.
  + Potential specification impact:
    - Configuration of UE-specific resources available in each network energy saving state and dynamic indication of a network energy saving state. Configuration(s) and procedure(s) related to CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
    - UE assistance information report
    - Dynamic signaling design to reduce transmission of these UE specific channels/signals, by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not able to use resources in all network energy saving states.
  + Potential impact to other WG
    - RLM/RRM measurement procedure based on periodic CSI-RS

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reduction of time occasions or synchronization of UE specific signal/channels can be performed based on following options:
    - Option 1) RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
    - Option 2) UE specific, and group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals

#### Proposal #2-3C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)
  + UE can send an uplink signal to transition a gNB from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.
  + In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.
    - cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell
  + Can be used in support of techniques #A-1,#A-2, #A-4, and other techniques. Exact design may depend on the supported technique.
  + Background:
    - UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment
    - If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.
    - For waking up gNBs in sleep mode or energy saving sate without regular transmission of SSBs/SIB1 in the presence of UEs demanding connectivity.
  + Potential specification impact:
    - Uplink signal design & related procedure for waking up a gNB
    - WUS signal/channel design
    - Mechanism on how UE can be informed about WUS signal/resource
    - UE measurements of PL of the gNB in the NES state for the UL power setting of UL WUS
    - UE behavior/assumption after sending WUS
    - Conditions for triggering the request, e.g., DL synchronization
    - Signaling for the request
    - UE behavior after transmitting the request
    - Specification enabling UEs to obtain necessary DL synchronization and measurements prior to the WUS in the uplinkDesign of WUS transmitted by UE
    - Conditions for triggering WUS transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is assumed that UE is synchronized with the gNB in the NES state or the gNB in the NES state is provided with timing information for detection of WUS.
  + Potential impact to other WGS
    - The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.
    - RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is dormant may be needed.

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)
  + Additional aspects of waking up gNB
    - Option 1: UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring (i.e., cell off/inactive period), or with sparse SSB/SIB1 transmission and RACH monitoring (e.g. 160ms)
      * UE may send WUS when moving to the coverage of this energy saving cell or there is need for fast access/synchronization/measurement
      * The WUS may trigger gNB’s normal operation, i.e. normal SSB/SIB1 transmission and RACH monitoring (e.g. 20ms)
      * UE reads SSB/SIB1 and perform random access if applicable after transmitting WUS
    - Option 2: UE WUS is used to wake up a gNB in an energy saving state without reception of semi-static UL transmissions
      * Wake up signal (WUS) is triggerd by MAC layer.
      * UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
    - Support of assistance information from the UEs intended to aid wake up operations by the gNBs.
    - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.
    - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - Wake up signal (WUS) is triggerd by MAC layer.
    - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.

#### Proposal #2-4C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX can be introduced for gNB has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB,
  + Enhancement of UE C-DRX which can be potentially align the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time
  + If UE DRX parameters, including cycle, on-duration and inactivity timers, can not be aligned to a cell specific setting due to different QoS requirements, cell-wise alignment on DRX offset for UE DRX operation can be utilized. Alignment to cell specific RS, e.g., SSB, is also useful to maximize BS inactivity/sleep time.
  + gNB entering into sleep mode for a period of time along with the indication of NES/non-NES state.
  + Background:
    - in case of DTX the BS can go to sleep mode, mainly light or micro sleep. The BS can temporarily switch off some parts of the BS Tx chain. Similar thinking applies for DRX, the BS can temporarily switch off some parts of the BS Rx chain. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - NR UE supports DRX operation as Rel-15 mandatory feature. Since UE will not monitor channels/signals from BS when outside DRX active time, there is corresponding restriction to BS activity time.
    - Alignment of UEs’ DRX active time to BS active time for common channels/signals (e.g. SSB) can be useful to minimize total BS active time. Yet, UE’s setting of DRX cycle, on-duration and inactivity timers are subject to QoS requirement of the UE’s data service, and alignment on DRX offset would be more feasible to accommodate different services and QoS requirements.
    - Without knowing the gNB state, a UE may still receive DL channels and transmit UL channels resulting in unnecessary UE power consumption. In addition, the gNB may miss unknown UL signals (e.g., SR/CG PUSCH) resulting in UL performance loss.
    - Currently gNB cannot enter into sleep mode based on various parameters like load and UE arrival rate, especially dynamic adaptation. Also, NR doesn’t support the mechanisms to deal with preconfigured operation to UE, if the gNB enters into sleep mode. An indication about irregular or abrupt adaptation of gNB entering sleep mode helps the UE to avoid unnecessary transmission/reception of signal/channel including preconfigured ones.
  + Potential specification impact:
    - when the network pauses transmission, common control channels as well as CSI-RS used for either mobility or for other purposes.Introduction of mechanism/signaling to enable inactive opportunity for gNB
    - Configuration and indication of gNB’s DTX/DRX information to UE
    - UE behavior/procedure when gNB’s DTX/DRX is in operation
    - Defining DTX/DRX pattern for gNB.
    - Mechanisms to align C-DRX configuration of UE, such as signaling design to align the C-DRX configuration.
    - Mechanism to wake up gNB from DTX/DRX
    - Configuration and indication of gNB’s DTX/DRX cycle information to UE
    - UE behavior/procedure when gNB’s DTX/DRX cycle is in operation
    - Design of DTX/DRX pattern
    - Adaptation of DTX/DRX by DL indication/WUS triggering
    - Impact on periodic signal/channel transmission
    - A set of cell-specific DRX configuration, including at least DRX offset value(s), in SIB
    - A mechanism of triggering adaptation for UE to align with the indicated cell-specific DRX configuration, e.g. DRX offset value
    - Configuration of DRX cycle aligned with the DTX/DRX cycle configuration/pattern used at the gNB for network energy saving
    - Dynamic L1/L2 indication to UE on the DTX mode/configuration applied at gNB and/or for switching to a DRX cycle corresponding to network energy saving
    - impact on preconfigured operations at the UE such as Harq codebook, SSB etc
      * UE transmit/receive by resuming the preconfigured operation upon gNB switching ON
    - Mechanism for indicating the network energy states in current or future time periods.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Impact from BS DTX/DRX onto legacy UEs has to be assessed. Impact onto Rel. 18 idle/inactive UEs can be kept to zero if the BS performs DTX outside of SSB/SI transmission instants. The same applies when BS performs DRX outside the RO slots.
    - For, introduction of mechanism/signaling to enable inactive opportunity for gNB,
      * when it is done in a UE-specific manner(e.g. for connected mode Rel-18 UEs), no impact to legacy UEs.
      * when it is done in a legacy UE-transparent manner(e.g. for legacy UEs in idle and/or connected mode), no impact to legacy UEs.
    - N/A since if legacy UE’s DRX offset cannot be adjusted by the new adaptation mechanism, BS is expected to reconfigure UE’s DRX setting or accommodate UE’s active time durationsLegacy UEs may incur longer access delays or unable to access the cell in some BS inactive states.
  + Potential impact to other WGS
    - impact of BS DTX/DRX on RAN 2 and RAN 3 specifications, in terms of BS DTX/DRX patterns definition and in terms of BS DTX/DRX patterns exchange across neighbor BSs.Introduction of mechanism/signaling to enable inactive opportunity for gNB can have at least RAN2 impact and possibly RAN3 (up to RAN3 discussions).
    - RAN2: Inclusion of cell-specific DRX configuration, including at least DRX offset value(s), in SIB

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-4: Adaptation of DTX/DRX
  + DRX offset configuration at BS
    - Offset value can be aligned with or close to SS burst location so as to minimize total BS active time for transmitting UE data and common channels/signals
  + DTX/DRX cycle configuration/pattern at the BS
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the BS.
    - Joint or separate configuration of DTX and DRX mode at the gNB is considered.
    - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.
    - cell-specific DTX/DRX operation may be different between Idle mode and connected mode
    - This may include association between WUS for gNB and the cell-specific DTX/DRX
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication
  + This may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced MAC CE and long DRX commend MAC CE. Cell-specific signaling can be based on paging PDCCH or paging early indication (DCI format 2\_7).
  + gNB sleep mode indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.
    - Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;
    - Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel
  + The indication may include monitoring occasion for the next BS state indication.
  + This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
  + This may include group common signaling for the indication of adapted active/inactive state
  + If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.

Several companies suggested to merge #A-5 into #A-4.

#### Proposal #2-5C

Description to be expected to be captured into TR (if technique is agreeable to be captured).

* ~~Technique #A-5: Adaptation of BS inactive state~~
  + ~~gNB entering into sleep mode for a period of time along with the indication of active/inactive state.~~
  + ~~Background:~~
    - ~~[To be filled]~~
  + ~~Potential specification impact:~~
    - ~~[To be filled]~~
  + ~~Additional considerations/aspects (including any impact to legacy UEs, if any):~~
    - ~~[To be filled]~~
  + ~~Potential impact to other WGS~~
    - ~~[To be filled]~~

Additional description intended to aid evaluations (not part of agreement)

* Technique #A-5: Adaptation of BS inactive state
  + ~~gNB sleep mode indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.~~
    - ~~Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;~~
    - ~~Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel~~
  + ~~The indication may include monitoring occasion for the next BS state indication.~~
  + ~~This may include support of semi-static and/or dynamic gNB active/inactive state adaptation.~~
  + ~~This may include group common signaling for the indication of adapted active/inactive state~~
  + ~~If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.~~

### [CLOSED] 3rd Round Discussions

Moderator suggests moving all “potential specification impact” and “Additional considerations/aspects (including any impact to legacy UEs, if any)” out of the initial agreement and to the additional information for now. The potential specification impact likely requires further edits and compressing duplicate information.

For the description to be agreed, moderator suggest focusing on the actual technique general description + background + potential impact to other WG

#### Proposal #2-1D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #A-1 Adaptation of common signals and channels
  + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities.
  + Background:
    - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission is one promising way to get the benefits.
    - NR has provided flexible configuration for downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell.
  + Potential impact to other WG
    - RAN2:
      * The higher layer configuration of the common control and broadcast signals and the UL resource for RACH
      * initial access procedure when the cell uses different periodicity of downlink common and broadcast signals
    - RAN3:
    - RAN4:
      * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #A-1 Adaptation of common signals and channels
  + Potential specification impact:
    - UE behavior for network access, such as initial access, measurements, RRM, and mobility, when informed about adaptation of common signals and channels. There is need to relax UE requirements to accommodate longer access or failure report latency, lower measurement accuracy and higher handover failure rate, due to the reduced availability of common channel/signals.
    - Mechanism on how UE can be informed about adaptation of common signals and channels
    - For adapting periodicity/availability of uplink random access opportunities, specification impact includes provisioning of adaptable RACH opportunities for Rel-18 UEs and associated RACH procedure.
    - DL indication mechanisms to inform UE of adaptation of common signals and channels.
    - Impact to TTI of system information blocks in RAN2 is expected if longer periodicities of SSB or SIB1 are to be supported.
    - Impact to paging occasion and paging frame definition in RAN2 is expected if enhancements to paging are to be supported.
    - Enabling UEs to adapt to the varying periodicity or transmission pattern of the common signals or channels; e.g., specification enabling UEs to enhance initial access performance to counter the impact due to increased SSBs/SIB1 periodicity.
    - Mechanisms to indicate/trigger the adaptation of the periodicity and/or a transmission pattern of downlink common and broadcast signals, including assistance of DL indication from network, UL WUS sent from UE
    - Impact on UL RO
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The legacy UEs may not operate in the cell with this technique. Legacy UEs may not recognize the adaptation of common signal and channel; e.g., initial access of legacy UEs expecting 20 ms SSB periodicity might fail with an increased SSB periodicity.
    - The UE assumptions on the measurements on the SSB by legacy UE for initial access, RLM, and RRM for mobility may get impacted.
    - The potential UE transitions to out-of-sync state when the periodicity of SSB is longer than the minimum duration in RAN4, e.g., 160 ms.
    - For adapting periodicity/availability of uplink random access opportunities, there is no impact to legacy UEs.
    - Legacy UE’s behavior for cell detection, RRM and RLM measurements, and random access do not change. Network implementation may avoid potential impact on legacy UEs by employing adaptation properly.
    - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.
    - Cell measurement is related to SSB periodicity. If legacy UE cannot be indicated the change of serving/neighbor cell SSB periodicity (due to new adaptation mechanism), there is impact to measurement accuracy (if UE cannot detect the correct periodicity) or longer latency for measurement outcome or hand-over, which can cause mobility performance degradation to legacy UE.
    - Legacy UE determine paging/cell common PDCCH occasions based on SIB1 configuration. If a new adaptation mechanism other than SI update mechanism is introduced, it is possible legacy UE cannot be notified of the change, and PO and common PDCCH monitoring will be failed.
  + The following options are various methods of adaptation for Technique #A-1a.
    - Option 1) introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH, or PSS and SSS with partial PBCH
    - Option 2) Different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH
    - Option 3) Transmission occasion of one or more common signals/channels of specific periods can be skipped.
    - Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, more than one periodicity are expected to potentially provide longer inactivity periods for the gNB.
    - Option 5) Support of configuration of longer periodicity (than what is currently supported) of common signals and/or uplink random access opportunities
    - Option 5a) Provisioning of additional uplink random access opportunities for Rel-18 UEs.
    - Option 6) The varying periodicity and/or dynamically changing a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.
    - Option 7) Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly ROs can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.
    - Option 8) Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.
    - Option 9) Simplified DL signals in lieu of SSBs or prior to SSBs to improve the initial access performance significantly while letting the periodicity of transmission be large enough for NES, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.
    - Option 10) support of a long period (rather than the period as the same as the SSB period) of search space
    - Option 11) support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead

#### Company Comments on Proposal #2-1D

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | To our understanding, the background part will describe the current status, and get the motivation of enhancement, so the second paragraph seem lack of enhancing motivation part, our modification are as following in blue text.   * + Background:     - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission is one promising way to get the benefits.     - NR has provided flexible configuration for downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell. However, SI update mechanism requires long time for adaption, and can not provide flexible gNB inactive opportunity based on cell status.   For the impact to other WG part, modifications are made in blue text.   * + Potential impact to other WG     - RAN2:       * The higher layer configuration of the common control and broadcast signals and the UL resource for RACH related to adaptation.       * initial access procedure when the cell uses different periodicity of downlink common and broadcast signals     - RAN3:     - RAN4:       * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.       * The UE measurement performance based on SSB may be affected. |
| CEWiT | The adaptation of common signals and channels should consider all aspects such as simplified version of downlink common and broadcast signalsas given in option 1 and scheduling of SIB1 using SSB as given in option 11, which is not very clear with the main description and hence we suggest to generalize the main claim as follows:  Technique #A-1 Adaptation of common signals and channels  Adapting the periodicity and/or a transmission pattern (when applicable), **structure and scheduling** of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities. |
| vivo | We support CMCC’s updates. Besides, we suggest the following update in red since initial access procedure not only related with downlink common signals and broadcast signals but also uplink common channgels:   * + Potential impact to other WG     - RAN2:       * The higher layer configuration of the common control and broadcast signals and the UL resource for RACH related to adaptation.       * initial access procedure ~~when the cell uses different periodicity of downlink common and broadcast signals~~ related to adaptation of common signals and channels |
| Spreadtrum | For “Additional considerations/aspects (including any impact to legacy UEs, if any)”, all aspects can be summarized as “it is not backward compatible”, but current version is fine. |
| CATT | We are OK with Moderator’s proposal but does not agree with CMCC’s update. The dynamic adaptation of the periodicity of DL common/broadcast signals would have impact to UEs (in particular legacy UEs), which should be well studied before it is included. |
| Nokia/NSB | We are fine with this proposal and the background updates proposed by CMCC. |
| Lenovo | We suggest following modification for background part:   * + Background:     - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels ~~less often can enable~~ may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission is one promising way to get the benefits.     - NR has provided flexible configuration for downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell. However, the SI update procedure requires multiple signaling (e.g. paging DCI, PDCCH/PDSCH for SI) with longer latency and accordingly, it is not suitable for flexible adaptation. |
| QCOM5 | **On periodicity adaptation**, it is not clear whether such adaptation is needed. From our understandings, the spec might already enable any implementation for the actual periodicity since the periodicity is just UE assumption. For example, for SSB, while UE assumes 20ms during initial access, gNB actually might transmits SSB at 160ms periodicity. Furthermore, what is the scale of the adaptation?   * Adapting ~~the periodicity and/or~~ a transmission pattern (when applicable) of downlink common and broadcast signals,   + - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy~~; increasing the periodicity of transmission is one promising way to get the benefits~~.   **On impacting to other WG**, the impact to RAN2 is not clear to us. In particular, RAN2 RRC signalling would be needed for any technique anyway, which can be discussed during WI.   * + - RAN2:       * ~~The higher layer configuration of the common control and broadcast signals and the UL resource for RACH~~       * ~~initial access procedure when the cell uses different periodicity of downlink common and broadcast signals~~   **On general note**: we don’t think there is the need to make agreement on the text in the proposal from “The following is additional description of a potential energy saving technique #xyz intended to help companies perform evaluations and further understand the various of the technique.” to the end of the proposal. |
| Samsung | 1. Avoid any assessment at this stage, e.g., ‘promissing’ In the first bullet under ‘background’:   -----  “In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission is one way to get the benefits.”  ----- |
| InterDigital | We are fine with proposal #2-1D |
| DOCOMO | We are fine with CMCC’s update on potential WGs impact. |
| Ericsson3 | Given the timeline for checking the proposals, we assume the “additional description of a potential energy saving technique” will be discussed separately for all the subsequent proposals.  Below is our comment on the proposal itself.  We suggest below updates to reflect capture the uplink aspect more accurately.   * Technique #A-1 Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities.   + Background:     - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels less often and/or reception of random-access signals less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission is one promising way to get the benefits.     - NR has provided flexible configuration for downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell.   + Potential impact to other WG     - RAN2:       * The higher layer configuration of the common control and broadcast signals and the UL resource for RACH       * initial access procedure when the cell uses different periodicity of downlink common and broadcast signals or RACH procedure when additional RACH opportunities are provided for Rel-18 UEs     - RAN3:     - RAN4:       * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| LG Electronics | **On the main bullet**: We are fine with the moderator’s version.  @ Qualcomm: Adaptation of SSB periodicity is not only for initial access UE but also for idle/connected UE, and is currently configured by RRC signaling. **If periodicity will be removed from the main bullet based on Qualcomm’s comment,** we would suggest to remove periodicity both for DL and UL. Otherwise, we are OK with the main bullet as it is.   * + Adapting ~~the periodicity and/or~~ a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the ~~periodicity/~~transmission pattern/availability of uplink random access opportunities.   **On “background”**: We agree with Qualcomm’s comment that we can remove “; increasing the periodicity of transmission is one promising way to get the benefits”, but disagree with the revision from CMCC and Lenovo for the second bullet. For the first bullet, we think Lenovo’s suggestion seems to be better.   * + Background:     - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels ~~less often can enable~~ may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy~~; increasing the periodicity of transmission is one promising way to get the benefits~~.     - NR has provided flexible configuration for downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell.   **On Potential impact to other WG**: We tend to agree with Qualcomm in that the first bullet for RAN2 is too broad. Nevertheless, it doesn’t make any harm to capture it at this stage. The second bullet needs clarification since “different periodicity” doesn’t seem to be clear.   * + Potential impact to other WG     - RAN2:       * The higher layer configuration of the common control and broadcast signals and the UL resource for RACH       * initial access procedure when the cell uses different periodicity of downlink common and broadcast signals   [LG Electronics] Needs clarification of “different periodicity”. Does it mean DL common channel #1 (e.g., SSB) can have a different periodicity from another DL common channel #2 (e.g., SIB1)? Or, does it mean DL common channel #1 (e.g., SSB) can have a different periodicity from the periodicity of the same DL common channel #1 (e.g., SSB) supported by legacy specification? |
| ZTE, Sanechips | Okay with the version suggested by CMCC. Besides, we think the periodicity adaptation should be considered in this technique. |
| Intel | We suggest following revision to background information:   * + Background:     - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels less ~~often~~ frequently can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; increasing the periodicity of transmission or considering a transmission pattern with longer inactivity period is one promising way to get the benefits.     - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with ~~NR has provided flexible configuration for~~ downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. ~~On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell~~   **The following comment applies to all Proposals:**  Also we suggest to simply agree to the proposal to be captured to the TR~~instead of agreeing on the intent to capture~~. For techniques that may not provide useful power saving gains, RAN1 can provide observations and conclusions as such. That is equally valuable information to capture into the TR as well.   * ~~The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.~~ Agree to the following potential energy saving technique to be captured to the TR.   We also suggest to also remove the background aspects from the agreement, if it is a bottleneck for achieving consensus. There would be more value in agreeing even small pieces of information with WG impact, rather than having nothing. |
| Huawei, HiSilicon | In general it is good shaping and we thank for FL efforts.  For the impact on other WGs, we think only critical aspect that may need RAN2/RAN3/RAN4 to consider/study/feedback. RAN1 does not need to identify everything that is expertise of other WGs, and   * the signaling/configuration aspect, we agree some previous reply that they can be discussed in WI thus not needed here. Configuration is always feasible. * The performance requirement aspect, is also something RAN4 will normally look into thus not needed here. Note that there is no TU for RAN4 for this SI thus we are not aiming for RAN4 to significantly study anything during SI.   We therefore consider the following can be reference for other WG(s):  **In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI. (*this can be a note in header and no need to repeat for every technique*)**   * Technique #A-1 Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities.     - RAN2:   initial access procedure |
| MediaTek | Thanks moderator for the updated description. Some comments on background and potential impact to other WG:   * Background:   + We haven’t reach the conclusion whether extending the periodicity of common signals/channels is “promising” or “beneficial”. At this stage, we would like to suggest capturing only technical descriptions for Background bullet:   “Transmission of common signal and channels less often can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy, which can be achieved by increasing the periodicity of transmission ~~is one promising way to get the benefits~~.”   * Potential impact to other WG   + For common signals/channels, there are higher layer configurations available and the adaptation can be done by system information update. In this regard, RAN2 impact is *additionally* higher layer configuration subject to “*if additional adaptation mechanism is adopted*”:   “If additional adaptation mechanism is adopted, ~~The~~ there may require additional higher layer configuration of the common control and broadcast signals and the UL resource for RACH” |

#### Proposal #2-2D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.
    - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - gNB may enter into sleep mode for a period of time along with the indication of network energy saving or non enery saving state, e.g., in terms of start time and duration.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * RLM/RRM measurement procedure based on periodic CSI-RS
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Potential specification impact:
    - Configuration of UE-specific resources available in each network energy saving state and dynamic indication of a network energy saving state. Configuration(s) and procedure(s) related to CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
    - UE assistance information report
    - Dynamic signaling design to reduce transmission of these UE specific channels/signals, by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not able to use resources in all network energy saving states.
  + Reduction of time occasions or synchronization of UE specific signal/channels can be performed based on following options:
    - Option 1) RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
    - Option 2) UE specific, and group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals

#### Company Comments on Proposal #2-2D

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| Company | Comments |
| CMCC | Currently, the background part is not about what current spec support and the motivation. It seems to be one specific specification impact.   * + Background:     - gNB may enter into sleep mode for a period of time along with the indication of network energy saving or non enery saving state, e.g., in terms of start time and duration.       * Comment:This should be moved to specification impacts.     - The semi-static configured UE specific channels/signals require gNB for periodic transmission or reception once they are activated, even when there is no UE traffic. Dynamically adapting transmission or reception of such signals/channels can provide more flexible gNB inactive opportunity. |
| vivo | We agree with CMCC’s comments. Besides, we suggest the following minor updates:   * + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.     - Potential list of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).   We don’t think all these UE specific resource need further enhancement. One or more may be selected finally from these potential list. |
| Spreadtrum | It seem a part of DTX/DRX, since it also means the gNB sleep. |
| CATT | We are OK with Moderator’s proposal. We don’t agree with the update suggested by companies. NR has the UE-specific control of measurement and monitoring of UE-specific signals/channels through DRX with the UE procedures. |
| Nokia/NSB | The proposal seem fine from our perspective. In our understanding, the dynamic adaptation of UE specific signals and channels could have RAN2 impacts, depending on RAN1 decision to inform the UE about dynamic reduction/omission of the above listed transmissions. |
|  | 1) RAN2 may have measurement procedure impact. In case of RAN4, the impact would be UE measurement performance, e.g.,:  --------   * + Potential impact to other WG     - RAN2: UE measurement procedure based on periodic CSI-RS; Higher layer configuration of UE-specific signals and channels to support dynamic adaptation of time occasions     - RAN3:     - RAN4: Performance requirements for UE measurement based on periodic CSI-RS   ------- |
| InterDigital | We share similar understanding with CMCC regarding the background. We suggest including the following description (modified from CMCC’s suggestion) under background of Proposal #2-2D:   * + Background:     - The semi-static configured UE specific channels/signals require gNB ~~for~~ to perform periodic transmission or reception once they are activated, even when there is no UE traffic. Configuring UE specific signals and channels available in each network energy saving state and d~~D~~ynamically signaling to the UE when adapting transmission or reception of such signals/channels can provide more flexible gNB inactive opportunity. |
| Ericsson3 | We suggest below updates.   * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Reducing/omitting the number of time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.     - List of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).   + Background:     - gNB may enter into sleep mode for a period of time along with the potential indication of network energy saving or non energy saving state, e.g., in terms of start time and duration.   + Potential impact to other WG     - RAN2: Configuration and procedures related to dynamic adaptation of one or more UE-specific signals/channels     - RAN3:     - RAN4:       * RLM/RRM measurement procedure based on periodic CSI-RS     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| LG Electronics | **On the main bullet**: As we commented previously, “synchronizing the UE specific signal and channel transmission reception” is unclear and any proponents for that phrase didn’t respond to our comment. So, we would suggest to remove it.   * + Reducing/omitting the number of time occasions for the UE specific resources ~~and synchronizing the UE specific signal and channel transmission reception~~ during periods of low activity. |
| ZTE, Sanechips | Omitting the number of not correct.   * + Reducing/omitting ~~the number of~~ time occasions for the UE specific resources and synchronizing the UE specific signal and channel transmission reception during periods of low activity.   Agree with CMCC about the comment on background part.  The following bullet can be removed.   * Technique #A-2: Dynamic adaptation of UE specific signals and channels   + Potential specification impact:     - ~~Configuration of UE-specific resources available in each network energy saving state and dynamic indication of a network energy saving state.~~ Configuration(s) and procedure(s) related to CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS). |
| Huawei, HiSilicon | With a similar reason as the response to #2-1D, we do not identify critical aspect for this techniques that needs other WGs particularly to look into. |

#### Proposal #2-3D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)
  + UE can send an uplink signal to transition a gNB from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.
  + In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.
    - Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell
  + Can be used in support of other techniques. Exact design may depend on the supported technique.
  + Background:
    - UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment
    - If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.
    - For waking up gNBs in sleep mode or energy saving sate without regular transmission of SSBs/SIB1 in the presence of UEs demanding connectivity.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.
      * RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is dormant may be needed.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)
  + Potential specification impact:
    - Uplink signal design & related procedure for waking up a gNB
    - WUS signal/channel design
    - Mechanism on how UE can be informed about WUS signal/resource
    - UE measurements of PL of the gNB in the NES state for the UL power setting of UL WUS
    - UE behavior/assumption after sending WUS
    - Conditions for triggering the request, e.g., DL synchronization
    - Signaling for the request
    - UE behavior after transmitting the request
    - Specification enabling UEs to obtain necessary DL synchronization and measurements prior to the WUS in the uplinkDesign of WUS transmitted by UE
    - Conditions for triggering WUS transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is assumed that UE is synchronized with the gNB in the NES state or the gNB in the NES state is provided with timing information for detection of WUS.
  + Additional aspects of waking up gNB
    - Option 1: UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring (i.e., cell off/inactive period), or with sparse SSB/SIB1 transmission and RACH monitoring (e.g. 160ms)
      * UE may send WUS when moving to the coverage of this energy saving cell or there is need for fast access/synchronization/measurement
      * The WUS may trigger gNB’s normal operation, i.e. normal SSB/SIB1 transmission and RACH monitoring (e.g. 20ms)
      * UE reads SSB/SIB1 and perform random access if applicable after transmitting WUS
    - Option 2: UE WUS is used to wake up a gNB in an energy saving state without reception of semi-static UL transmissions
      * Wake up signal (WUS) is triggerd by MAC layer.
      * UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
    - Support of assistance information from the UEs intended to aid wake up operations by the gNBs.
    - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.
    - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - Wake up signal (WUS) is triggerd by MAC layer.
    - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.

#### Company Comments on Proposal #2-3D

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| Company | Comments |
| CMCC | Comments in line and with blue text.   * + Background:     - UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment     - If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.       * Comment: this seems to be potential performance impact, not background.     - For waking up gNBs in sleep mode or energy saving sate without regular transmission of SSBs/SIB1 in the presence of UEs demanding connectivity.   + Potential impact to other WG     - RAN2: How to provide wake up configuration for idle/inactive mode UEs. |
| CEWiT | The main description should be general enough to include all possibilities as given in potential specification impacts and additional aspects. The UE may need to obtain necessary DL synchronization and measurements prior to the transmission of WUS. Hence we suggest to update the main proposal as follows:   * Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)   + UE can send an uplink signal to transition a gNB from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.   + In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.     - Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell **or cells with simplified DL signals such as simplified SSB.**   + Can be used in support of other techniques. Exact design may depend on the supported technique.   Also, for the additional aspects of waking up gNB, the assistance information from the UEs can be from connected UEs to their connected gNBs (gNB in energy saving state or anchor UE), hence we suggest to update the “Additional aspects of waking up Gnb” as follows:   * + Additional aspects of waking up gNB     - Option 1: UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring (i.e., cell off/inactive period), or with sparse SSB/SIB1 transmission and RACH monitoring (e.g. 160ms)       * UE may send WUS when moving to the coverage of this energy saving cell or there is need for fast access/synchronization/measurement       * The WUS may trigger gNB’s normal operation, i.e. normal SSB/SIB1 transmission and RACH monitoring (e.g. 20ms)       * UE reads SSB/SIB1 and perform random access if applicable after transmitting WUS     - Option 2: UE WUS is used to wake up a gNB in an energy saving state without reception of semi-static UL transmissions       * Wake up signal (WUS) is triggerd by MAC layer.       * UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.     - Support of assistance information such as **mobility, location information** from the UEs **either directly or though the anchor gNB** intended to aid wake up operations by the gNBs.     - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.     - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).     - Wake up signal (WUS) is triggerd by MAC layer.     - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request. |
| vivo | We have the following comments and suggested updates:   * + Background:     - UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs.~~, as some companies also indicate in the first-round comment~~     - If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.     - For waking up gNBs in sleep mode or energy saving sate without regular transmission of SSBs/SIB1 in the presence of UEs demanding connectivity.   + Potential impact to other WG     - RAN2:       * How to provide WUS configuration for idle/inactive UEs       * Conditions to trigger WUS transmissions       * UE WUS transmission related procedure (e.g., resource selection, power determination and adjustment and etc.)       * UE behavior after transmitting WUS     - RAN3:       * UE WUS configuration exchange across neighbor gNBs       * Coordination on determination of gNB state across neighbor gNBs that receives WUS     - RAN4:       * The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.       * RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is dormant may be needed.   Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| CATT | It is important to identify that the gNB in the dormant power sate/energy saving state to be triggered to wake up by UE WUS is NOT the serving cell of the UE.   * Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)   + UE can send an uplink signal to trigger the transition a gNB from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.   + In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.     - Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell     - UE is required to acquire the timing of the gNB in dormant power sate/energy saving state to set the Tx time and power of UL WUS |
| Nokia/NSB | We would like to clarify whether the RAN2 impacts foreseen are related to UE signaling? For e.g., the of mechanism/signaling to enable inactive opportunity for gNB, are these signaling from the gNB to the UE? |
| QCOM5 | Based on earlier online discussion, there was no need to discuss NES state. Note that sleep state may be clear from discussion in 9.7.1. Alternatively, we can use the term “inactive state”.   * UE can send an uplink signal to transition a gNB from a ~~dormant power state/energy saving state~~ sleep state to an active state   The following main bullet is already captured in the earlier bullet. Furthermore, the sub-bullet contains details that are not needed at this state.   * + ~~In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.~~     - ~~Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell~~   We can simplify the background as follows:   * + Background:     - With the support of WUS, the gNB might go to a sleep state (where it does not transmit nor receive signal/channel) outside of the WUS monitoring occasions.     - ~~UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment~~     - ~~If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.~~     - ~~For waking up gNBs in sleep mode or energy saving sate without regular transmission of SSBs/SIB1 in the presence of UEs demanding connectivity.~~ |
| Samsung | 1) Assuming ‘UE WUS’ and ‘cell WUS’ are the same, we suggest to use ‘UE WUS’ (or WUS) only.  2) Regarding “Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK)”, the highlight yellow text is not clear to us, the original text comes from our proposal and the update is not aligned with the intention. We suggest the following update.  -----   * Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)   + UE can send an uplink signal to transition a gNB from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.   + In order to wake up gnb during periods of low activity, wake up signal (WUS) can be transmitted by the UE.     - Cell WUS triggered by MAC ~~and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK).~~     - UE can transmit semi-static configured UL channels X symbols after cell WUS transmission or UE monitors PDCCH carrying an ACK for cell WUS     - For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell   -----  3) WUS triggering procedure as already mentioned in the general description may have RAN2 impact:  -----   * + Potential impact to other WG     - RAN2: WUS triggering procedure     - RAN3:     - RAN4:       * The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.       * RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is dormant may be needed.   ----- |
| InterDigital | We are generally fine with the changes suggested by vivo |
| Ericsson3 | We suggest below updates.   * Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)   + UE can send an uplink signal to request transitioning of a gNB from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states.   + In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.     - For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell   + Background:     - A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.   + Potential impact to other WG     - RAN2: Configuration and procedures related to wake up of gNB triggered by UE wake up signal     - RAN3:     - RAN4:       * The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.       * RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is dormant may be needed.     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| LG Electronics | **On the main bullet**: We agree with Qualcomm’s comment on the second bullet which seems not necessary at all, and also agree with CATT’s revision for which it is captured for UE to require UL TX timing and power before sending WUS. Therefore, here is our suggestion. In addition, as Qualcomm pointed out, dormant power state/energy saving state is not cleary defined, so we prefer “inactive state” instead.   * + UE can send an uplink signal to trigger the transition of a gNB from a ~~dormant power state/energy saving state~~ inactive state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.   + UE is required to acquire the timing of the gNB in inactive state to set the TX timing and power of UE WUS   + ~~In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.~~     - ~~Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell~~   + Can be used in support of other techniques. Exact design may depend on the supported technique.   **On “background”**: We support revision suggested from Qualcomm and prefer using inactive state than using sleep state.  **On potential impact to other WG**: We should avoid to use the terms such as NES state or dormant state before defining them. For the first bullet, it is unclear to us that serving cell and the gNB in the NES state are the same or different.   * + - RAN4:       * ~~The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.~~       * RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is ~~dormant~~ in inactive state may be needed. |
| ZTE, Sanechips | As we comment before, how gNB response to WUS is FFS.It is better not to mandate gNB has to transition outside of ES state soon after WUS reception.   * + UE can send an uplink signal to indicate ~~transition~~ a gNB to transition from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states.   [comment] the following details are not needed at this stage. Furthermore, the WUS format can be sequence based, which should not be precluded before further discussion.   * + In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.     - ~~Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK)~~. ~~For idle/inactive/connected UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell~~ |
| Intel | Suggest the following change:   * + Background:     - UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment     - If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated. Waking up ~~For waking up~~ gNBs in sleep mode or energy saving sate ~~without regular transmission of SSBs/SIB1~~ in the presence of UEs demanding connectivity will be one of the use cases. |
| Huawei, HiSilicon | With similar reason we consider the following can be reference for RAN2.   * Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)   + UE can send an uplink signal as a trigger e.g. to transition a gNB from a dormant power state/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in all RRC states and for idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission.   + The trigger may be made by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). The technique may be used in support of other techniques.   + ~~In order to wake up gnb during periods of low activity, wake up signal (WUS) transmitted by the UE.~~     - ~~Cell WUS triggered by MAC and the UL transmission in semi-statically configured UL resources or the PDCCH containing ACK). For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell~~   + ~~Can be used in support of other techniques. Exact design may depend on the supported technique.~~     - RAN2:       * the trigger condition and higher-layer UE procedure of WUS triggered cell activation.     - RAN4:       * ~~The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.~~       * ~~RAN4 input on~~ feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is not performing normal operation, e.g. SSB transmission ~~dormant may be needed~~. |

#### Proposal #2-4D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #A-4: Adaptation of DTX/DRX
  + DTX/DRX can be introduced for gNB has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB,
  + Enhancement of UE C-DRX which can be potentially align the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time
  + kgNB entering into sleep mode for a period of time along with the indication of network energy saving state or non-energy saving state.
  + Background:
    - In case of DTX the BS can go to sleep mode, mainly light or micro sleep. The BS can temporarily switch off some parts of the BS Tx chain. Similar thinking applies for DRX, the BS can temporarily switch off some parts of the BS Rx chain. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - NR UE supports DRX operation as Rel-15 mandatory feature. Since UE will not monitor channels/signals from BS when outside DRX active time, there is corresponding restriction to BS activity time.
    - Alignment of UEs’ DRX active time to BS active time for common channels/signals (e.g. SSB) can be useful to minimize total BS active time. Yet, UE’s setting of DRX cycle, on-duration and inactivity timers are subject to QoS requirement of the UE’s data service, and alignment on DRX offset would be more feasible to accommodate different services and QoS requirements. If UE DRX parameters, including cycle, on-duration and inactivity timers, cannot be aligned to a cell specific setting due to different QoS requirements, cell-wise alignment on DRX offset for UE DRX operation can be utilized. Alignment to cell specific RS, e.g., SSB, is also useful to maximize BS inactivity/sleep time.
    - Without knowing the gNB state, a UE may still receive DL channels and transmit UL channels resulting in unnecessary UE power consumption. In addition, the gNB may miss unknown UL signals (e.g., SR/CG PUSCH) resulting in UL performance loss.
    - Currently gNB cannot enter into sleep mode based on various parameters like load and UE arrival rate, especially dynamic adaptation. Also, NR doesn’t support the mechanisms to deal with preconfigured operation to UE, if the gNB enters into sleep mode. An indication about irregular or abrupt adaptation of gNB entering sleep mode helps the UE to avoid unnecessary transmission/reception of signal/channel including preconfigured ones.
  + Potential impact to other WGS
    - RAN2:
      * BS DTX/DRXpatterns definition and BS DTX/DRX patterns exchange across neighbor BSs.
      * Introduction of mechanism/signaling to enable inactive opportunity for gNB
      * Inclusion of cell-specific DRX configuration, including at least DRX offset value(s), in SIB
    - RAN3:
      * BS DTX/DRX patterns definition and BS DTX/DRX patterns exchange across neighbor BSs.
      * Introduction of mechanism/signaling to enable inactive opportunity for gNB
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #A-4: Adaptation of DTX/DRX
  + DRX offset configuration at BS
    - Offset value can be aligned with or close to SS burst location so as to minimize total BS active time for transmitting UE data and common channels/signals
  + DTX/DRX cycle configuration/pattern at the BS
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the BS.
    - Joint or separate configuration of DTX and DRX mode at the gNB is considered.
    - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.
    - cell-specific DTX/DRX operation may be different between Idle mode and connected mode
    - This may include association between WUS for gNB and the cell-specific DTX/DRX
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication
  + The technique may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced MAC CE and long DRX commend MAC CE. Cell-specific signaling can be based on paging PDCCH or paging early indication (DCI format 2\_7).
  + gNB sleep mode indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.
    - Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;
    - Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel
  + gNB sleep mode indication may include monitoring occasion for the next BS state indication.
  + If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.
  + Potential specification impact:
    - when the network pauses transmission, common control channels as well as CSI-RS used for either mobility or for other purposes.Introduction of mechanism/signaling to enable inactive opportunity for gNB
    - Configuration and indication of gNB’s DTX/DRX information to UE
    - UE behavior/procedure when gNB’s DTX/DRX is in operation
    - Defining DTX/DRX pattern for gNB.
    - Mechanisms to align C-DRX configuration of UE, such as signaling design to align the C-DRX configuration.
    - Mechanism to wake up gNB from DTX/DRX
    - Configuration and indication of gNB’s DTX/DRX cycle information to UE
    - UE behavior/procedure when gNB’s DTX/DRX cycle is in operation
    - Design of DTX/DRX pattern
    - Adaptation of DTX/DRX by DL indication/WUS triggering
    - Impact on periodic signal/channel transmission
    - A set of cell-specific DRX configuration, including at least DRX offset value(s), in SIB
    - A mechanism of triggering adaptation for UE to align with the indicated cell-specific DRX configuration, e.g. DRX offset value
    - Configuration of DRX cycle aligned with the DTX/DRX cycle configuration/pattern used at the gNB for network energy saving
    - Dynamic L1/L2 indication to UE on the DTX mode/configuration applied at gNB and/or for switching to a DRX cycle corresponding to network energy saving
    - impact on preconfigured operations at the UE such as Harq codebook, SSB etc
      * UE transmit/receive by resuming the preconfigured operation upon gNB switching ON
    - Mechanism for indicating the network energy states in current or future time periods.
    - The technique may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
    - The technique may include group common signaling for the indication of adapted active/inactive state
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Impact from BS DTX/DRX onto legacy UEs has to be assessed. Impact onto Rel. 18 idle/inactive UEs can be kept to zero if the BS performs DTX outside of SSB/SI transmission instants. The same applies when BS performs DRX outside the RO slots.
    - For, introduction of mechanism/signaling to enable inactive opportunity for gNB,
      * when it is done in a UE-specific manner(e.g. for connected mode Rel-18 UEs), no impact to legacy UEs.
      * when it is done in a legacy UE-transparent manner(e.g. for legacy UEs in idle and/or connected mode), no impact to legacy UEs.
    - N/A since if legacy UE’s DRX offset cannot be adjusted by the new adaptation mechanism, BS is expected to reconfigure UE’s DRX setting or accommodate UE’s active time durationsLegacy UEs may incur longer access delays or unable to access the cell in some BS inactive states.

#### Company Comments on Proposal #2-4D

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | Modify a sentence for the following,   * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX can be introduced for gNB to increase ~~has~~ the inactive opportunity ~~to be inactive~~. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB,   The background part has some duplication, as commented below.   * + Background:     - ……     - Alignment of UEs’ DRX active time to BS active time for common channels/signals (e.g. SSB) can be useful to minimize total BS active time. Yet, UE’s setting of DRX cycle, on-duration and inactivity timers are subject to QoS requirement of the UE’s data service, and alignment on DRX offset would be more feasible to accommodate different services and QoS requirements. If UE DRX parameters, including cycle, on-duration and inactivity timers, cannot be aligned to a cell specific setting due to different QoS requirements, cell-wise alignment on DRX offset for UE DRX operation can be utilized. Alignment to cell specific RS, e.g., SSB, is also useful to maximize BS inactivity/sleep time.       * Comment: the highlighted sentence seems to be duplicated with previous sentence.     - Without knowing the gNB state, a UE may still receive DL channels and transmit UL channels resulting in unnecessary UE power consumption. In addition, the gNB may miss unknown UL signals (e.g., SR/CG PUSCH) resulting in UL performance loss.     - Currently gNB cannot enter into sleep mode based on various parameters like load and UE arrival rate, especially dynamic adaptation. Also, NR doesn’t support the mechanisms to deal with preconfigured operation to UE, if the gNB enters into sleep mode. An indication about irregular or abrupt adaptation of gNB entering sleep mode helps the UE to avoid unnecessary transmission/reception of signal/channel including preconfigured ones.       * Comment: This bullet and above bullet seems to provide motivation of defining DTX/DRX or indication of inactive state of gNB, so as to make common understanding of gNB and UE. So they can be re-organized together. |
| Spreadtrum | * + D~~R~~TX offset configuration at BS     - Offset value can be aligned with or close to SS burst location so as to minimize total BS active time for transmitting UE data and common channels/signals   Is it the typo, since there is “transmitting UE data and common channels/signals”?  In addition, it has merged cell activation/deactivation. In our view, DTX/DRX can be replaced by gNB sleep, without differentiating DTX or DRX.  Finally, “BS” should be changed to “gNB” for alignment. |
| CATT | We are OK with moderator’s proposal without further change. |
| InterDigital | We suggest the following addition under Proposal #2-4D:   * + Potential impact to other WGs     - RAN2:       * Introduction of mechanism/signaling to enable inactive opportunity for gNB and related DRX adaptation |
| Ericsson3 | We suggest below updates. It seems many of the techniques such as aligning different UE’s DRX configurations, aligning on duration with SSB are already feasible with current specification, hence we do not see them needed in high-level description. Proponents can still discuss those as part of the additional descriptions if needed.Also the text about QoS requirements/preconfigured operation is RAN2 domain, so prefer to leave it out of RAN1 discussions.   * Technique #A-4: Adaptation of DTX/DRX   + With DTX/DRX,gNB has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or has to have only limited transmission/receptions such as sparse SSB, uplink RACH/SR, etc/   + Enhancement of UE C-DRX which can be potentially align the DRX cycle configured for UEs in connected mode [or idle/inactive mode] can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time   + gNB entering into sleep mode for a period of time along with the possible indication of network DTX/DRX.   + Background:     - In case of DTX/DRX, the BS can go to sleep mode, such as deep, light or micro sleep. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.     - Since UE may not monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.   + Potential impact to other WGS     - RAN2:       * BS DTX/DRX patterns definition and potential BS DTX/DRX patterns exchange across neighbor BSs.       * Introduction of mechanism/signaling to enable inactive opportunity for gNB       * Possible definition and Inclusion of cell-specific DRX configuration, including e,g, DRX offset value(s)     - RAN3:       * BS DTX/DRX patterns definition and possible BS DTX/DRX patterns exchange across neighbor BSs.       * Introduction of mechanism/signaling to enable inactive opportunity for gNB     - RAN4:     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| LG Electronics | **On the main bullet**: We suggest some editorial changes, as follows.   * + DTX/DRX can be introduced for gNB to have ~~has~~ the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels~~, or only limited transmission such as sparse SSB,~~   + Enhancement of UE C-DRX which can be potentially aligned with the DRX cycle configured for UEs in connected mode or idle/inactive mode can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time   + gNB entering into sleep mode for a period of time along with the indication of ~~network energy saving state or non-energy saving~~ active/inactive state.   **On “background”**: We think simplified version as follows seems to be sufficient.   * + Background:     - In case of DTX the BS can go to sleep mode, mainly light or micro sleep. The BS can temporarily switch off some parts of the BS Tx chain. Similar thinking applies for DRX, the BS can temporarily switch off some parts of the BS Rx chain. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.     - NR UE supports DRX operation as Rel-15 mandatory feature. ~~Since UE will not monitor channels/signals from BS when outside DRX active time, there is corresponding restriction to BS activity time.~~     - ~~Alignment of UEs’ DRX active time to BS active time for common channels/signals (e.g. SSB) can be useful to minimize total BS active time. Yet, UE’s setting of DRX cycle, on-duration and inactivity timers are subject to QoS requirement of the UE’s data service, and alignment on DRX offset would be more feasible to accommodate different services and QoS requirements. If UE DRX parameters, including cycle, on-duration and inactivity timers, cannot be aligned to a cell specific setting due to different QoS requirements, cell-wise alignment on DRX offset for UE DRX operation can be utilized. Alignment to cell specific RS, e.g., SSB, is also useful to maximize BS inactivity/sleep time.~~     - ~~Without knowing the gNB state, a UE may still receive DL channels and transmit UL channels resulting in unnecessary UE power consumption. In addition, the gNB may miss unknown UL signals (e.g., SR/CG PUSCH) resulting in UL performance loss.~~     - ~~Currently gNB cannot enter into sleep mode based on various parameters like load and UE arrival rate, especially dynamic adaptation. Also, NR doesn’t support the mechanisms to deal with preconfigured operation to UE, if the gNB enters into sleep mode. An indication about irregular or abrupt adaptation of gNB entering sleep mode helps the UE to avoid unnecessary transmission/reception of signal/channel including preconfigured ones.~~   **On Potential impact to other WGs**: Signaling details should be up to RAN2.   * + Potential impact to other WGS     - RAN2:       * BS DTX/DRXpatterns definition and BS DTX/DRX patterns exchange across neighbor BSs.       * Introduction of mechanism/signaling to enable inactive opportunity for gNB       * Inclusion of cell-specific DRX configuration~~, including at least DRX offset value(s), in SIB~~     - RAN3:       * BS DTX/DRX patterns definition and BS DTX/DRX patterns exchange across neighbor BSs.       * Introduction of mechanism/signaling to enable inactive opportunity for gNB |
| ZTE, Sanechips | * Technique #A-4: Adaptation of DTX/DRX   DTX/DRX can be introduced for gNB to increase ~~has~~ the opportunity to be inactive  We don’t think the following bullet is needed at this stage. And “network energy saving state” is overused.   * + kgNB entering into sleep mode for a period of time along with the indication of network energy saving state or non-energy saving state. |
| Intel | Some revisions are suggested to Proposal   * + DTX/DRX transmission mode can be introduced for gNB so that it has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB,   + Enhancement of UE C-DRX where DRX cycle configured for UEs in connected mode or idle/inactive mode can be aligned to potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time |
| Huawei, HiSilicon | * Technique #A-4: Adaptation of DTX/DRX   + DTX/DRX can be introduced for gNB during which ~~has the opportunity to be inactive. During the inactive duration~~, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or only limited transmission such as sparse SSB   + Enhancement of UE C-DRX which can ~~be~~ potentially align the DRX cycle configured for UEs in connected mode or idle/inactive mode ~~can potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time~~   + ~~kgNB entering into sleep mode for a period of time along with the indication of network energy saving state or non-energy saving state.~~      - RAN2/RAN3:       * BS DTX/DRX patterns definition and BS DTX/DRX patterns exchange across neighbor BSs.       * ~~Introduction of mechanism/signaling to enable inactive opportunity for gNB~~       * ~~Inclusion of cell-specific DRX configuration, including at least DRX offset value(s), in SIB~~     - ~~RAN3:~~       * ~~BS DTX/DRX patterns definition and BS DTX/DRX patterns configuraitons exchange across neighbor BSs.~~       * ~~Introduction of mechanism/signaling to enable inactive opportunity for gNB~~ |
| MediaTek | Thanks moderator for the updated version. We support the version with suggested revisions from CMCC (removal of yellow highlighted part) and InterDigital (revision for RAN2 impact) |

#### Proposal #2-6B

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #A-6 Adaptation of SSB
  + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving by the cell ON/OFF.
  + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + Background:
    - Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. The DRX was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell enhancements.
    - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 and SSB-less operations are promising way to get the benefits.
    - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.
    - For SSB/SIB-less operations, the carrier is deployed without SSB/SIB1. The UE can get synchronization and system information from other carriers for such carrier(s).
  + Potential impact to other WGS
    - RAN2:
      * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 of SSB-less operation
      * Handling of transmissions of SIB1 if changes to SIB1 transmission cycle is changed.
      * System information enhancement to provide other carriers’ information and carrier selection principles for UE.
      * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.
      * For SIB-less carrier, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.
    - RAN3:
      * Cross carrier synchronization for single carrier operation.
      * , and the
    - RAN4:
      * feasibility of only on-demand SSB transmission for time/frequency synchronization.
      * RLM and RRM measurements from on-demand transmission of SSB.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #A-1b Adaptation of common signals and channels
  + The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:
    - Option 1) DL signals to aid initial access and discovery of cells in lieu of SSBs.
    - Option 2) mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.
    - [Option 3) cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.]
      * [moderator note: Repeat of #3-1B?]
    - [Option 4) offloading SIB of the SIB-less cell to another cell. and SIB-less operation is for non-CA case.]
      * E.g., UE on SIB-less cell can obtain SIB via common channels transmitted on another cell.
      * [moderator note: Repeat of #3-1B?]
    - Option 5) Simplified DL signals in lieu of SSBs providing necessary synchronization prior to the UE trigger for on-demand SSBs/SIB1 and potentially enhancing initial access performance altogether significantly, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.
  + Potential specification impact:
    - On-demand SSB/SIB1 transmission or SSB/SIB1-less operation might have impact to the behavior of wUEs for network access, such as initial access, measurements, RRM, mobility, and so on.
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - Conditions and procedures on how UE sends on-demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - The UE assumptions and behavior of SSBs/SSB1 transmission for on-demand or no transmission of SSBs/SIB1 need to be specified
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Details of on-demand triggering, including the triggering signaling design, triggering signaling configuration, and the triggering procedure.
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Reduced or no availability of SSBs/SIB1 would result in performance degradation in terms of UE normal access to the network, such as initial access, measurements, RRM, mobility and so on.
    - Specification enabling UEs capable of performing initial access with on-demand SSBs/SIB1 transmission, e.g., defining simplified DL signals preceding a UE trigger to aid initial access and discovery of cells in lieu of regular SSBs
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - DL signaling mechanism that enable UE to synchronize with the gNB for sending the on demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - For on-demand SSB/SIB, the potential specification in RAN1 may include:
      * Uplink trigger signal design
      * Downlink signal/channel [which is to aid initial access and discovery of cells in lieu of SSBs] design, if supported.
      * SSB-less carriers operation is used for inter-band CA. Due to the fact that SSB-less carriers operation is already supported in intra-band CA, the existing procedure in RAN1 defined for intra-band case can be re-used in general.
      * For SIB-less carrier, there is no obviously specification impact in RAN1.
    - Signaling design for on-demand SSBs/SIB1 transmission indication, UE’s or network’s behavior in response to the on-demand indication, etc.
    - System information enhancement to provide other cell’s information and cell selection for UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The potential impact of RRM/RLM measurements and network access delay by UEs.
    - Impact on legacy UEs: legacy UEs might not recognize such a technique.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UE unable camp or perform initial access on cell with long periods of inactivity
    - Whether this technique is applicable to Connected, Inactive, or Idle mode

#### Company Comments on Proposal #2-6B

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| --- | --- |
| Company | Comments |
| CMCC | There is a typo in the first sub-bullet of background, “The DRS~~X~~ was introduced for cell”.  For Potential impact to other WGS, Cross carrier synchronization for single carrier operation has RAN4 impacts, not for RAN3, sorry for the typo. It is moved from RAN3 to RAN4.   * + - RAN3:       * Cross carrier synchronization for single carrier operation.       * , and the     - RAN4:       * feasibility of only on-demand SSB transmission for time/frequency synchronization.       * RLM and RRM measurements from on-demand transmission of SSB.       * Cross carrier synchronization for single carrier operation. |
| vivo | It seems there is overlapping part with Proposal #3-1D for multi-carrier case. Suggest to move multi-carrier related issue to Proposal#3-1D. This proposal focuses on single carrier case. |
| Spreadtrum | Also have feeling that some techniques in frequency domain are like that in time domain. For example, SSB reduction and on-demand SSB can be applied to SCell and PCell both. Merging frequency and time domain may save our time and reduce our efforts. |
| CATT | We are generally OK expect with the impact to other working goups  RAN3: The cross-carrier synchronization is not required for on-demand or no-transmission SSB/SIB1. Thus, we should not include this until RAN1 confirm the solution require cross-carrier synchronization.  RAN4: The on-demand SSB/SIB is used for identification of gNB in network energy saving state. It is not used for the serving cell of UEs. Thus, RLM should not be included. |
| QCOM5 | This technique should focus on on-demand SSB/SIB1 since SSB/SIB1-less will be discussed later in frequency domain. In addition, we suggest adding “from UE” in the 2nd bullet:   * + On-demand SSBs/SIB1 transmissions ~~or SSB/SIB1-less operations~~ may also enable long periods of inactivity at the gNB to achieve gNB energy saving by the cell ON/OFF.   + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request from UE.   For the background, the 1st bullet is not needed while the last bullet can be discussed under SSB-less carrier in frequency domain:   * + - ~~Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. The DRX was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell enhancements.~~     - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 ~~and SSB-less operations~~ are promising way to get the benefits.     - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.     - ~~For SSB/SIB-less operations, the carrier is deployed without SSB/SIB1. The UE can get synchronization and system information from other carriers for such carrier(s).~~   On impact to other WGs:   * + - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 ~~of SSB-less operation~~       * Handling of transmissions of SIB1 if changes to SIB1 transmission cycle is changed.       * System information enhancement to provide other carriers’ information and carrier selection principles for UE.       * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.   ~~For SIB-less carrier, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.~~ |
| Samsung | 1. Avoid any assessment at this stage, e.g., ‘promissing’ in the second bullet under ‘background’: 2. Typo: DRX 🡪 DRS (Discovery Reference Signal)   -----   * + Background:     - Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. The ~~DRX~~DRS (Discovery Reference Signal) was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell enhancements.     - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 and SSB-less operations are ~~promising~~one way to get the benefits.     - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.     - For SSB/SIB-less operations, the carrier is deployed without SSB/SIB1. The UE can get synchronization and system information from other carriers for such carrier(s).   ----- |
| InterDigital | We are fine with proposal #2-6B |
| Ericsson3 | We suggest below changes – DRX is for UE power savings – we are not sure the linkage to OFF state/UE discovery or the similarity of Rel-12 SCE.   * Technique #A-6 Adaptation of SSB   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving by the cell ON/OFF.   + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.   + Background:     - Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB operating with sparse/no SSBs/SIB1 transmission.     - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 and SSB-less operations are promising way to get the benefits.     - For on-demand SSBs/SIB1 transmissions, UE can request transmission of normal SSB/SIB1 in case SSB and SIB1 are needed.     - For SSB/SIB-less operations, the carrier may be deployed without SSB/SIB1. The UE may get synchronization and system information from same/other carriers for such carrier(s).   + Potential impact to other WGS     - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 or SSB-less operation       * Handling of transmissions of SIB1 if changes to SIB1 transmission cycle is changed.       * System information enhancement to provide other carriers’ information and carrier selection principles for UE, and possible procedure for UE initial access, idle mode camping, paging monitoring.,       * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.       * For SIB-less carrier, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.       * Handling of legacy and new UEs, new RLM/RRM procedures, etc     - RAN3:       * Cross carrier synchronization for single carrier operation.     - RAN4:       * feasibility of only on-demand SSB transmission for time/frequency synchronization.       * RLM and RRM measurements from on-demand transmission of SSB.     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| LG Electronics | **On the main bullet**: “cell ON/OFF” can be removed since the term itself is unclear and wihout turning OFF the cell, gNB can operate with on-deman SSB/SIB1.   * + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving ~~by the cell ON/OFF~~.   + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.   **On general aspect**: As other companies pointed out, we need a clarification on the difference between frequency domain technique and time domain technique here. From our understanding, in frequency domain technique, multiple carrier are operated from UE’s perspective, not from gNB’s perspective. |
| ZTE, Sanechips | The following is suggested.   * Technique #A-6 Adaptation of SSB   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving ~~by the cell ON/OFF.~~     - For SSB/SIB-less operations, the carrier/cell is deployed without SSB/SIB1. The UE can get synchronization and system information from other carriers for such carrier(s)/cell(s). |

#### Company Comments on Proposal #2-5C and #2-7A

It was suggested by numerology companies to merge Proposal #2-5C and #2-7A into other Proposals. Please provide comments if you do not agree and think a separate technique description is needed. If so, the also provide the exact description to potential agreement.

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| --- | --- |
| Company | Comments |
| QCOM5 | Proposal #2-5C and #2-7A are not needed. |

### [ACTIVE] 4th Round Discussions

For proposal #2-5C and #2-7A, moderator assumes they no longer need to be discussed.

For all other proposals, moderator has provided an update based on comments received.

#### Proposal #2-1E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #A-1 Adaptation of common signals and channels
  + Adapting transmission pattern (when applicable), structure and scheduling of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the transmission pattern/availability of uplink random access opportunities.
  + Background:
    - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels or reception of random-access signals may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.
    - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell. However, the SI update procedure requires multiple signaling (e.g. paging DCI, PDCCH/PDSCH for SI) with longer latency and accordingly, it is not suitable for flexible adaptation.
  + Potential impact to other WG
    - RAN2:
      * ~~The higher layer configuration of the common control and broadcast signals and the UL resource for RACH related to adaptation~~
      * ~~Initial access procedure when the cell uses different periodicity of downlink common and broadcast signals or RACH procedure when additional RACH opportunities are provided for Rel-18 UEs related to adaptation of common signals and channels~~
    - RAN3:
    - RAN4:
      * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.
      * The UE measurement performance based on SSB may be affected.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #2-1F

* Technique #A-1 Adaptation of common signals and channels
  + Adapting the periodicity and/or transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities.
  + Background:
    - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels or reception of random-access signals may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.
    - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities.
  + Potential impact to other WG
    - RAN2:
      * Initial access procedure when the cell uses different periodicity of downlink common and broadcast signals/channels from what is supported in NR
    - RAN3:
    - RAN4:
      * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.
      * The UE measurement performance based on SSB may be affected.

#### Proposal #2-1G

* Technique #A-1 Adaptation of common signals and channels
  + Adapting the transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the transmission pattern/availability of uplink random access opportunities.
  + Background:
    - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels or reception of random-access signals may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.
    - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access resources.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.
      * The UE measurement performance based on SSB may be affected.

#### Company Comments on Proposal #2-1E/F/G

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| --- | --- |
| Company | Comments |
| CMCC | We also agree that reducing SSB/SIB1 transmission for single carrier case will have impact on legacy UEs’ initial access performance, so it should be careful to apply such schemes to network with legacy UEs. But at this stage, it is not precluded for new deployment with only new UEs.  Currently, as described in TS38.213, for initial cell selection, a UE may assume that half frames with SS/PBCH blocks occur with a periodicity of 2 frames, which is 20ms. For this case, is it possible for gNB to use a periodicity of 160ms as commented by Qualcomm? If so, when a UE set a cell search window with less than 160ms on each carrier, it may fall to discover the cell, and combining between different 20ms occasions to improve SSB performance seems impossible, and even make the detection worse. The default 20ms assumption seems meaningless. We wonder whether this is the common understanding.  **If gNB has to transmit SSB at least in a repetition period of 20ms to meet the default SSB periodicity, adaption of SSB periodicity can be one potential technique, and needs to be included in the technique description.**  Then gNB can adapt its SSB periodicity and indicate implicitly or explicitly, so UE wants to access the cell can make detection accordingly and save UE power.  Therefore, we prefer to keep the periodicity part.   * Technique #A-1 Adaptation of common signals and channels   + Adapting the periodicity and/or a transmission pattern (when applicable), structure and scheduling of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/transmission pattern/availability of uplink random access opportunities. |
| LG Electronics | Just one comment for the second bullet of “Background”: The first two sentences seem to be duplicated since they are all pointing out SI update. The last sentence may not be needed.   * + - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. |
| DOCOMO | We are fine with FL’s summary and LGE’s update. |
| vivo | We have the following comments:   * + - 1. Adding back period into the main bullet. In NR Rel-15/16/17, period of common signal and channel is mainly semi-statically configured. To facilitate fast period adaptation, enhancement on signaling of period is needed.       2. We are not clear what the structure and scheduling mean here and the benefit for network energy saving. Suggest to remove them.   So we suggest the following revision:   * + Adapting period and/or transmission pattern (when applicable)~~, structure and scheduling~~ of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the transmission pattern/availability of uplink random access opportunities. |
| ZTE, Sanechips | We agree with CMCC and vivo that the periodicity adaptation of common signal/channel should be considered in the time domain techniques. For the impact on legacy UEs, solutions suggested by CMCC is promising.  For the “structure and scheduling”, we think the “structure ” has been included in “transmission pattern”, and “scheduling” is included in “cell common PDCCH”. Therefore, “structure and scheduling” is duplicated.  For the following impact on RAN2, we think it should be kept. Some update is suggested to address the comments in the last round of discussion.  Initial access procedure when the cell uses different periodicity from periodicity supported by legacy specification for ~~of~~ downlink common and broadcast signals |
| Fraunhofer | @CMCC we share this understanding. As vivo and ZTE also suggested, we agree with adding periodicity back in the description. |
| Lenovo | We suggest to keep periodicity adaptation, since different SSB/SI/paing subsets in beam sweeping may be transmitted with different periodicities. Also, we suggest removing the duplicated text.   * + Adapting periodicity and/or transmission pattern (when applicable), structure and scheduling of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the transmission pattern/availability of uplink random access opportunities.   + Background:     - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels or reception of random-access signals may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.     - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access opportunities. ~~On top of the flexibility, there is also SI update mechanism that can adapt the parameters for the cell.~~ However, the SI update procedure requires multiple signaling (e.g. paging DCI, PDCCH/PDSCH for SI) with longer latency and accordingly, it is not suitable for flexible adaptation. |
| CEWiT | In reply to Vivo’s comment, Since the motivation of the proposal is to adapt the common signals and channel in order to achieve energy saving. Various techniques are proposed by companies to adapt the common channels and signals for e.g., simplified signals (such as only PSS etc), adaptation of CORESET 0, scheduling enhancements of common signal, varying periodicity and many more. These techniques are covered in addition details to provide detailed description for simulations. Thus the main proposal should cover all the discussed aspects related to adaptation of common signals & channels as given in additional details. We don’t have any problem with inclusion of periodicity in the proposal but we suggest to keep the “scheduling and structure” in the proposal to cover various adaptations for the common signal and channels. Thus we suggest the main proposal intact as follows:   * Technique #A-1 Adaptation of common signals and channels   + Adapting periodicity, transmission pattern (when applicable), structure and scheduling of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the transmission pattern/availability of uplink random access opportunities. |
| Moderator | Updated to #2-1F based on comments.  Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Regarding “structure” and “scheduling”. Moderator agrees that “structure” might not be the best descriptive language. Let’s try to keep thing simple. As far as moderator understands, the current description does not seem to limit what CEWiT is proposing. |
| ITRI | We can agree on FL’s proposal in principle with updated information provided by LGE and vivo. |
| QCOM6 | Thanks very much FL for great effort.  On periodicity of the broadcast/common channels, we do not agree to capture it in the proposal.  @CMCC on “*For this case, is it possible for gNB to use a periodicity of 160ms as commented by Qualcomm? If so, when a UE set a cell search window with less than 160ms on each carrier, it may fall to discover the cell, and combining between different 20ms occasions to improve SSB performance seems impossible, and even make the detection worse*.” – We don’t think the observation is correct. With some implementation, the search window does not need to cover the whole actual SSB periodicity. In the example of 160ms, the window of 20ms is possible for SSB detection. The main issues with long SSB peridocity are UE complexity and acquisition latency.  As being said, the spec has flexibility for NW to implement different periodicity settings already.  The definition of “uplink random access opportunities” in the first bullet and the 2nd sub-bullet under background is not clear. We suggest updating it to “uplink random access ~~opportunities~~ resources”   * + - 1. With our view on periodicity adaptation, we suggest removing the following impact to RAN2.    RAN2:  • ~~Initial access procedure when the cell uses different periodicity of downlink common and broadcast signals/channels from what is supported in NR~~ |
| Apple | The potential RAN2 impact is not clear to us: “Initial access procedure when the cell uses different periodicity of downlink common and broadcast signals/channels from what is supported in NR”. What does “initial access procedure” mean here exactly? The 4-step or 2-step RACH procedure? The configuration signaling e.g. for PRACH occasions? Or something else? We wonder if there is something that needs to be fundamentally changed. Some clarification would be appreciated. |
| Moderator | Let’s just keep transmission pattern for now. From moderator’s perspective periodicity is just one of the characteristics of a transmission pattern. Transmission pattern should be generic enough to cover both aspects.  Deleted RAN2 impact.  Updated Proposal in #2-1G. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
|  |  |

#### Proposal #2-2E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting time occasions for the UE specific resources during periods of low activity.
    - Potential list of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - The semi-static configured UE specific channels/signals require gNB for periodic transmission or reception if they are activated. Configuring UE specific signals and channel available in each network energy saving state and dynamical adaptation of transmission or reception of signals/channels may provide more flexible gNB inactive opportunities.
  + Potential impact to other WG
    - RAN2:
      * UE measurement procedure based on periodic CSI-RS; Higher layer configuration of UE-specific signals and channels to support dynamic adaptation of time occasions
      * Configuration and procedures related to dynamic adaptation of one or more UE-specific signals/channels
    - RAN3:
    - RAN4:
      * Performance requirements of rUE measurements based on periodic CSI-RS
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #2-2F

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting time occasions for the UE specific resources during periods of low activity.
    - Potential list of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - The semi-static configured UE specific channels/signals require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more flexible gNB inactive opportunities.
  + Potential impact to other WG
    - RAN2:
      * Configuration and procedures related to dynamic adaptation of one or more UE-specific signals/channels
    - RAN3:
    - RAN4:

#### Proposal #2-2G

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting time occasions for the UE specific resources during periods of low activity.
    - Potential list of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - The semi-static configured UE specific channels/signals may require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more opportunities for gNB to enter inactive state.
  + Potential impact to other WG
    - RAN2:
      * UE measurement procedure based on periodic CSI-RS
      * Configuration and procedures related to dynamic adaptation of one or more UE-specific signals/channels
    - RAN3:
    - RAN4:
      * Performance requirements of measurements based on periodic CSI-RS

#### Proposal #2-2H

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting time occasions for the UE specific resources during periods of low activity.
    - Potential list of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - The semi-static configured UE specific channels/signals may require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more opportunities for gNB to enter inactive state.
    - Except for positioning RS (PRS), the configu-rations for the listed UE-specific sig-nals/chennels are BWP-specific, and BWP adaptation framework can be utilized for dy-namic adaptation
  + Potential impact to other WG
    - RAN2:
      * UE measurement procedure based on periodic CSI-RS
      * Configuration and procedures related to enhanced dynamic adaptation of one or more UE-specific signals/channels
    - RAN3:
    - RAN4:
      * Performance requirements of measurements based on periodic CSI-RS

#### Company Comments on Proposal #2-2E/F/G/H

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| Company | Comments |
| CMCC | We are generally ok with the proposal. The highlight two sentences seem to be duplicated.   * + Potential impact to other WG     - RAN2:       * UE measurement procedure based on periodic CSI-RS; Higher layer configuration of UE-specific signals and channels to support dynamic adaptation of time occasions       * Configuration and procedures related to dynamic adaptation of one or more UE-specific signals/channels |
| LG Electronics | Editorial comment for **“Background”**   * + - The semi-static configured UE specific channels/signals require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more flexible gNB inactive opportunities.   For **Potential impact to other WG**: Considering periodic CSI-RS is one of candidate signals for dynamic adaptation, we suggest to leave out some impacts related to a specific signal at this stage. Two bullets under RAN2 seem overlapping.   * + - RAN2:       * Configuration and procedures related to dynamic adaptation of one or more UE-specific signals/channels     - RAN3:     - RAN4: |
| vivo | Suggest to remove “Higher layer configuration of UE-specific signals and channels to support dynamic adaptation of time occasions” since it is already covered by the second sub-bullet, i.e.   * + Potential impact to other WG     - RAN2:       * UE measurement procedure based on periodic CSI-RS; ~~Higher layer configuration of UE-specific signals and channels to support dynamic adaptation of time occasions~~       * Configuration and procedures related to dynamic adaptation of one or more UE-specific signals/channels |
| CEWiT | We are fine with the proposal |
| Moderator | Updated to #2-2F based on comments.  Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this. |
| ITRI | We are OK with FL’s proposal in principle, and we can support updated information provided by CMCC, LGE and vivo. |
| QCOM6 | We suggest some update:   * + Background:     - The semi-static configured UE specific channels/signals may require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more opportunities for gNB to enter inactive state ~~flexible gNB inactive opportunities~~. |
| Apple | We wonder the reason for removing “Performance requirements of rUE measurements based on periodic CSI-RS” for RAN4 impact. This is a valid point to consider in our view.  Along the same line, we think it is good to keep “UE measurement procedure based on periodic CSI-RS” in RAN2 impact. Even though it can be argued this is also covered by “procedures” in the 2nd sub-bullet, this is much more informative, and it is also important. |
| Moderator | There were some suggestions to leave out some of the more WG impact (performance, signaling). Moderator understands that depending on different companies one could view some as obvious impact, while one could view as non-obvious.  Since we will have disclaimer tha we can edit the impact later, and different WG should be able to decide whether something is obvious that will be done (if agree) during the WI, then moderator suggests to be more inclusive for now. One of the goals of getting an agreement is to provide as much information to other WGs. If so having the information seems to be favorable approach. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
| MediaTek | * On **Technique #A-2: Dynamic adaptation of UE specific signals and channels**, we would like to point out the configurations of the listed UE-specific signals/channels are BWP specific. For dynamic adaptation, existing BWP adaptation framework can be utilized, but some enhancements may be needed.  In this regard, the following update is suggested:  |  | | --- | | * + Background:     - The semi-static configured UE specific channels/signals may require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more opportunities for gNB to enter inactive state.     - Except for positioning RS (PRS), the configurations for the listed UE-specific signals/chennels are BWP-specific, and BWP adaptation framework can be utilized for dynamic adaptation.   + Potential impact to other WG     - RAN2:       * UE measurement procedure based on periodic CSI-RS       * Configuration and procedures related to enhanced dynamic adaptation of one or more UE-specific signals/channels | |
| Moderator | Updated in #2-2H |
| LG Electronics | For the added bullet under “Background” from MediaTek, it is not clear how BWP switching mechanism can enable adaptation of signals/channels. However, if it will be contained as in Proposal #2-2H, we suggest some more wording as follows.   * + Background:     - The semi-static configured UE specific channels/signals may require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more opportunities for gNB to enter inactive state.     - Except for positioning RS (PRS), the configu-rations for the listed UE-specific sig-nals/chennels are BWP-specific, and BWP adaptation framework can be utilized for dy-namic adaptation for a UE capable of multiple BWPs and dynamic BWP switching |

#### Proposal #2-3E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)
  + UE can send an uplink signal to request transitioning of a gNB sleep state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.
  + UE may be required to acquire the timing of the gNB in inactive state to set the TX timing and power of UE WUS
  + ~~In order to wake up gnb during periods of low activity, wake up signal (WUS) can be transmitted by the UE.~~
    - ~~Cell WUS triggered by MAC.~~
    - ~~UE can transmit semi-static configured UL channesl X symbols after cell WUS transmission or UE monitors PDCCH carrying an ACK for cell WUS.~~
    - ~~For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell or cells with simplified DL signals such as simplified SSB.~~
    - ~~UE is required to acquire the timing of the gNB in dormant power sate/energy saving state to set the Tx time and power of UL WUS.~~
  + Can be used in support of other techniques. Exact design may depend on the supported technique.
  + Background:
    - With the support of WUS, the gNB might go to a sleep state (where it does not transmit nor receive signal/channel) outside of the WUS monitoring occasions. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.
    - ~~UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment~~
    - ~~Waking up gNBs in sleep mode or energy saving state in the presence of UEs demanding connectivity will be one of the use cases~~.
  + Potential impact to other WG
    - RAN2:
      * Signaling details of wakeup configuration for idle/inactive mode UEs.
      * Conditions to trigger WUS transmissions, and any WUS transmission related procedures and behaviors.
    - RAN3:
      * WUS configuration exchange across neighboring gNBs
      * Coordination on determination of gNB state across neighbor gNB that receive WUS
    - RAN4:
      * The minimum requirements and the performance of UE synchronization to both serving cell and the gNB in the NES state.
      * RAN4 input on feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is not performing normal operation, e.g. SSB transmission.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #2-3F

* Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)
  + UE can send an uplink signal to request transitioning of a gNB inactive state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.
  + Can be used in support of other techniques. Exact design may depend on the supported technique.
  + Background:
    - With the support of WUS, the gNB might go to a inactive state (where it does not transmit nor receive signal/channel or where it only transmits and receives limited signals) outside of the WUS monitoring occasions. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.
  + Potential impact to other WG
    - RAN2:
      * Signaling details of wakeup configuration
      * Conditions to trigger WUS transmissions, and any WUS transmission related procedures and behaviors.
    - RAN3:
      * WUS configuration exchange across neighboring gNBs
      * Coordination on determination of gNB state across neighbor gNB that receive WUS
    - RAN4:
      * Feasibility of obtaining time/frequency synchronization and power setting for UEs that are sending WUS to the gNB that is not performing normal operation, e.g. SSB transmission.

#### Proposal #2-3G

* Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)
  + UE can send an uplink signal to request transitioning of a gNB inactive state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.
  + Can be used in support of other techniques. Exact design may depend on the supported technique.
  + Background:
    - With the support of WUS, the gNB might go to an inactive state (where it does not transmit nor receive signal/channel or where it only transmits and receives limited signals) outside of the WUS monitoring occasions. A gNB in an inactive state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.
  + Potential impact to other WG
    - RAN2:
      * Signaling details of wakeup configuration
      * Conditions to trigger WUS transmissions, and any WUS transmission related procedures and behaviors.
    - RAN3:
      * WUS configuration exchange across neighboring gNBs
      * Coordination on determination of gNB state across neighbor gNB that receive WUS
    - RAN4:
      * Feasibility of obtaining time/frequency synchronization and power setting for UEs that are sending WUS to the gNB that does not transmit SSB.

#### Company Comments on Proposal #2-3E/F/G

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| Company | Comments |
| CMCC | Some comment for the background description.   * + Background:     - With the support of WUS, the gNB might go to a sleep state (where it does not transmit nor receive signal/channel) outside of the WUS monitoring occasions or go to energy saving state where it only transmits or receives limited signals. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink WUS signal from the UE. |
| LG Electronics | For **main bullet** and **“Background”**: We prefer to use the unified terminology, e.g., inactive state, for the highlighted parts below.   * + UE can send an uplink signal to request transitioning of a gNB sleep state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.   + UE may be required to acquire the timing of the gNB in inactive state to set the TX timing and power of UE WUS   + Can be used in support of other techniques. Exact design may depend on the supported technique.   + Background:     - With the support of WUS, the gNB might go to a sleep state (where it does not transmit nor receive signal/channel) outside of the WUS monitoring occasions. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.   For **Potential impact to other WG**: For the first bullet of RAN2 impact, this technique is not chieve to idle/inactive mode. The first bullet of RAN4 impact is not necessary and the second bullet of RAN4 impact seems sufficient.   * + - RAN2:       * Signaling details of wakeup configuration.       * Conditions to trigger WUS transmissions, and any WUS transmission related procedures and behaviors.     - RAN3:       * WUS configuration exchange across neighboring gNBs       * Coordination on determination of gNB state across neighbor gNB that receive WUS     - RAN4:       * Feasibility of obtaining time/frequency synchronization for UEs that are sending WUS to the gNB that is not performing normal operation, e.g. SSB transmission. |
| DOCOMO | We are generally fine with the FL proposal, while we have comments on the background part. We are open to use the term of ‘energy saving state’, but some companies may prefer not to use it according to the previous round comments. In that case, we propose the following update, which also includes the CMCC’s proposal:   * + Background:     - With the support of WUS, the gNB might go to a sleep state (where it does not transmit nor receive signal/channel, or where it only transmits or receives limited signals) outside of the WUS monitoring occasions. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE. |
| Vivo | Here are our comments below:  We prefer using previous wording of dormant/energy saving state instead of sleep state. Sleep state may be misunderstood as sleep mode.   * Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)   + UE can send an uplink signal to request transitioning of a gNB ~~sleep~~ dormant/energy saving state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.   + UE may be required to acquire the timing of the gNB in idle/inactive state to set the TX timing and power of UE WUS   + ~~In order to wake up gnb during periods of low activity, wake up signal (WUS) can be transmitted by the UE.~~     - ~~Cell WUS triggered by MAC.~~     - ~~UE can transmit semi-static configured UL channesl X symbols after cell WUS transmission or UE monitors PDCCH carrying an ACK for cell WUS.~~     - ~~For idle/inactive UEs, the cell WUS can be used to trigger the SSB/SIB transmission on the “SSB-less or SIB-less” cell or cells with simplified DL signals such as simplified SSB.~~     - ~~UE is required to acquire the timing of the gNB in dormant power sate/energy saving state to set the Tx time and power of UL WUS.~~   + Can be used in support of other techniques. Exact design may depend on the supported technique.   + Background:     - With the support of WUS, the gNB might go to a dormant/energy saving state (where it does not transmit nor receive signal/channel) outside of the WUS monitoring occasions. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.     - ~~UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring, or with sparse SSB/SIB1 transmission and RACH monitoring. The typical case for a gNB to enter such a state is that there is no RRC\_connected UEs in the cell. Therefore, the usage of such a technique is mainly for idle/inactive UEs, as some companies also indicate in the first-round comment~~     - ~~Waking up gNBs in sleep mode or energy saving state in the presence of UEs demanding connectivity will be one of the use cases~~. |
| ZTE, Sanechips | We understand the intention of the following bullet, and we also agree that this is an important aspect to be considered. However, we think the following bullet can be captured in the subclause of “other aspects” instead of generic technique description. [it is also duplicated with the impact on RAN4]   * + UE may be required to acquire the timing of the gNB in inactive state to set the TX timing and power of UE WUS   For the background, the following is suggested.   * + - With the support of WUS, the gNB might go to a sleep state (where it does not transmit nor receive signal/channel, or transmit/receive limited signal/channel) outside of the WUS monitoring occasions. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.   For the impact on RAN2, the WUS sent by RRC connected state UE is missed.   * + Potential impact to other WG     - RAN2:       * Signaling details of wakeup configuration for idle/inactive/connected mode UEs.       * Conditions to trigger WUS transmissions, and any WUS transmission related procedures and behaviors. |
| Fraunhofer | Based on information in the second bullet, we suggest the following edit to the RAN4 impact sub-bullet   * + - RAN4:       * RAN4 input on feasibility of obtaining time/frequency synchronization and power setting for UEs that are sending WUS to the gNB that is not performing normal operation, e.g. SSB transmission. |
| Moderator | Updated proposal to #2-3F based on comments.  Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore removed any text related to this. |
| ITRI | We are generally OK with FL’s proposal. However, we suggest that the “sleep state” highlight in below can be discussed to be replaced by “inactivity state”, “a state other than active state” or something like that. Simailarly, “energy saving state” can be discussed to be replaced by “inactivity state”, “a state other than active state” or something like that   * Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)   + UE can send an uplink signal to request transitioning of a gNB sleep state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.   + UE may be required to acquire the timing of the gNB in inactive state to set the TX timing and power of UE WUS   + Can be used in support of other techniques. Exact design may depend on the supported technique.   + Background:   With the support of WUS, the gNB might go to a sleep state (where it does not transmit nor receive signal/channel) outside of the WUS monitoring occasions. A gNB in energy saving state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE |
| QCOM6 | Some update for terminology alignment  o Background:  With the support of WUS, the gNB might go to an inactive state (where it does not transmit nor receive signal/channel or where it only transmits and receives limited signals) outside of the WUS monitoring occasions. A gNB in ~~energy saving~~ an inactive state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.  It seems RAN4 impact is on sending WUS in SSB-less carrier. Also we should note that “normal operation” is not defined yet.   * + - RAN4:       * Feasibility of obtaining time/frequency synchronization and power setting for UEs that are sending WUS to the gNB that does not transmit SSB. ~~is not performing normal operation, e.g. SSB transmission~~. |
| Apple | We seem to be having a bit of terminology issue, inactive vs sleep vs energy saving state etc. We are fine with using “inactive state”, but we suggest moving the definition to the first bullet. It may not matter much which terminology we choose, as long as a proper definition is provided.   * + UE can send an uplink signal to request transitioning of a gNB inactive state (where it does not transmit or receive any signal/channel or where it only transmits and receives limited signals/channels) to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.   Then the following bullet can be changed accordingly:   * + - With the support of WUS, the gNB might go to a inactive state outside of the WUS monitoring occasions. A gNB in inactive state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.   For RAN3, we wonder if the following captures the intention better for the 2nd bullet:   * + - * Coordination on determination of gNB states across neighbor gNBs that support the reception of WUS |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
|  |  |

#### Proposal #2-4E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #A-4: Adaptation of DTX/DRX
  + With DTX/DRX, gNB has the opportunity be inactive . During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or ~~has to have only limited transmission/receptions such as sparse SSB, uplink RACH/SR, etc.~~
  + Enhancement of UE C-DRX where DRX cycle configured for UEs in connected mode or idle/inactive mode can be aligned to potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time
  + gNB entering into sleep mode for a period of time along with the possible indication of network DTX/DRX.
  + Background:
    - In case of DTX/DRX the BS can go to sleep mode, such as deep, light, or micro sleep. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - Since UE may not monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.
    - ~~Alignment of UEs’ DRX active time to BS active time for common channels/signals (e.g. SSB) can be useful to minimize total BS active time. Yet, UE’s setting of DRX cycle, on-duration and inactivity timers are subject to QoS requirement of the UE’s data service, and alignment on DRX offset would be more feasible to accommodate different services and QoS requirements. Alignment to cell specific RS, e.g., SSB, is also useful to maximize BS inactivity/sleep time.~~
    - ~~Without knowing the gNB state, a UE may still receive DL channels and transmit UL channels resulting in unnecessary UE power consumption. In addition, the gNB may miss unknown UL signals (e.g., SR/CG PUSCH) resulting in UL performance loss. Currently gNB cannot enter into sleep mode based on various parameters like load and UE arrival rate, especially dynamic adaptation. Also, NR doesn’t support the mechanisms to deal with preconfigured operation to UE, if the gNB enters into sleep mode. An indication about irregular or abrupt adaptation of gNB entering sleep mode helps the UE to avoid unnecessary transmission/reception of signal/channel including preconfigured ones.~~
  + Potential impact to other WGS
    - RAN2/RAN3:
      * gNB DTX/DRXpatterns definition and potential gNB DTX/DRX patterns exchange across neighbor gNBs.
      * ~~Possible definition and iInclusion of cell-specific DRX configuration, including e.g. DRX offset value(s)~~
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #2-4F

* Technique #A-4: Adaptation of DTX/DRX
  + With DTX/DRX, gNB has the opportunity to be inactive . During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels or has to keep limited transmission/receptions.
  + Enhancement of UE C-DRX where DRX cycle configured for UEs in connected mode or idle/inactive mode can be aligned, potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time.
  + gNB entering into sleep mode for a period of time along with the possible indication of network adaptation of DTX/DRX.
  + Background:
    - In case of DTX/DRX the BS can go to sleep mode, such as deep, light, or micro sleep. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - Since UE may monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.
  + Potential impact to other WGS
    - RAN2/RAN3:
      * gNB DTX/DRXpatterns definition and potential gNB DTX/DRX patterns exchange across neighbor gNBs.
    - RAN4:

#### Proposal #2-4G

* Technique #A-4: Adaptation of DTX/DRX
  + With DTX/DRX, gNB has the opportunity to be inactive . During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, and may have no transmission/reception or only keep limited transmission/reception.
  + Enhancement of UE C-DRX where DRX cycle configured for UEs in connected mode or idle/inactive mode can be aligned, potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time.
  + gNB entering into inactive state for a period of time along with the possible indication of network adaptation of DTX/DRX.
  + Background:
    - In case of DTX/DRX the BS can go to inactive state with different time granularities. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its inactivity will be limited. The alignment of the DRX cycles for the UEs can be done only via RRC re-configuration. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - Since UE may monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.
  + Potential impact to other WGS
    - RAN2/RAN3:
      * gNB DTX/DRX patterns definition and potential gNB DTX/DRX patterns exchange across neighbor gNBs.
    - RAN4:

#### Proposal #2-4H

* Technique #A-4: Adaptation of DTX/DRX
  + With DTX/DRX, gNB has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, and may have no transmission/reception or only keep limited transmission/reception.
  + Enhancement of UE C-DRX where DRX cycles or offsets configured for UEs in connected mode or idle/inactive mode can be aligned, potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time.
  + gNB entering into inactive state for a period of time along with the possible indication of network adaptation of DTX/DRX.
  + Background:
    - In case of DTX/DRX the BS can go to inactive state with different time granularities. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its inactivity will be limited. The alignment of the DRX cycles or offsets for the UEs can be done only via RRC re-configuration. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - Since UE may monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.
  + Potential impact to other WGS
    - RAN2/RAN3:
      * gNB DTX/DRX patterns/parameters definition and potential gNB DTX/DRX patterns exchange across neighbor gNBs.
    - RAN4:

#### Company Comments on Proposal #2-4E/F/G

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| --- | --- |
| Company | Comments |
| CMCC | Currently, we don’t have a clear picture of DTX and DRX, whether gNB stops transmission or reception completely or still has limited transmission or reception.  For UE C-DRX, UE may still do measurement or receive PDCCH with CRC scrambled other than those listed in TS38.321 section 5.7. Similarly, whether gNB has to transmit limited SSB for UE to keep synchronization is still not clear. So we propose to keep the modified sentence highlighted.   * Technique #A-4: Adaptation of DTX/DRX   + With DTX/DRX, gNB has the opportunity to be inactive . During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or has to keep limited transmission/receptions for UE synchronization or for response to the wake up request.~~has to have only limited transmission/receptions such as sparse SSB, uplink RACH/SR, etc.~~ |
| LG Electronics | For **main bullet**: Several editorial comments   * + With DTX/DRX, gNB has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels.   + Enhancement of UE DRX where DRX cycle configured for UEs in connected mode or idle/inactive mode can be aligned, potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time   + gNB entering into sleep mode for a period of time along with the possible indication of network DTX/DRX.   For **“Background”**: If I’m not mistaken, the following bullet should be resived as follows.   * + - Since UE may monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time. |
| ZTE, Sanechips | Agree with CMCC, it is too early to preclude the case that gNB may have limited transmission/reception during inactive duration. Since the signals/channels with limited transmission/reception is unclear, the functionality can be removed at this stage.  On top of CMCC’s version, the following is suggested.  With DTX/DRX, gNB has the opportunity to be inactive . During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or has to keep limited transmission/receptions ~~for UE synchronization or for response to the wake up request~~.~~has to have only limited transmission/receptions such as sparse SSB, uplink RACH/SR, etc.~~ |
| CEWiT | We suggest following update in the proposal \  “gNB entering into sleep mode for a period of time along with the possible indication of network adaptation of DTX/DRX. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Updated proposal to #2-4F based on comments. |
| ITRI | We are OK with FL’s proposal in principle. However, we think that we can focus on not to transmit/receive any signal during inactive duration in the very first step; and the limited transmission/reception during inactive duration may be further discussed. |
| Fujitsu | Similar to proposal #2-3F, the terminology, e.g., inactive state or sleep mode, need to be unified, for the following bullets   * + With DTX/DRX, gNB has the opportunity be inactive . During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, or ~~has to have only limited transmission/receptions such as sparse SSB, uplink RACH/SR, etc.~~   + gNB entering into sleep mode for a period of time along with the possible indication of network DTX/DRX.   + Background:     - In case of DTX/DRX the BS can go to sleep mode, such as deep, light, or micro sleep. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.   Suggest the following revision:   * + gNB entering into ~~sleep mode~~ inactive state for a period of time along with the possible indication of network DTX/DRX.   + Background:     - In case of DTX/DRX the BS can go to ~~sleep mode~~ inactive state, ~~such as deep, light, or micro sleep~~ with different time granularities. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for ~~its sleeping~~ it being inactive will be limited. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied. |
| Apple | We would like to suggest the following for the first bullet:   * + With DTX/DRX, gNB has the opportunity to be inactive . During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, and may have no transmission/reception or only keep limited transmission/reception.   The alignment of UE C-DRX is possible today with RRC configuration already, so it should be added to the background.   * + - In case of DTX/DRX the BS can go to sleep mode, such as deep, light, or micro sleep. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its sleeping will be limited. The alignment of the DRX cycles for the UEs can be done only via RRC re-configuration. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.   Editorial: there is a space missing between “DTX/DRX” and “patterns” in RAN2/RAN3 impact. |
| Moderator | Updated based on comments. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
| MediaTek | * On **Technique #A-4: Adaptation of DTX/DRX**, we see, in real network setting, data and VoIP are subject to different DRX cycles due to different QoS requirements. From our view, alignment of DRX offsets (while allowing different DRX cycles) is more feasible. In this regard, we would like to suggest the following revision:  |  | | --- | | * + Enhancement of UE C-DRX where DRX cycles or offsets configured for UEs in connected mode or idle/inactive mode can be aligned, potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time.   + gNB entering into inactive state for a period of time along with the possible indication of network adaptation of DTX/DRX.   + Background:     - In case of DTX/DRX the BS can go to inactive state with different time granularities. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its inactivity will be limited. The alignment of the DRX cycles or offsets for the UEs can be done only via RRC re-configuration. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.     - Since UE may monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.   + Potential impact to other WGS     - RAN2/RAN3:       * gNB DTX/DRX patterns/parameters definition and potential gNB DTX/DRX patterns exchange across neighbor gNBs. | |
| Moderator | Updated in #2-4H |
|  |  |

#### Proposal #2-6E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #A-6 Adaptation of SSB
  + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving by the cell ON/OFF.
  + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + Background:
    - Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. The DRX was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell enhancements.
    - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 and SSB-less operations are promising way to get the benefits.
    - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.
    - For SSB/SIB-less operations, the carrier is deployed without SSB/SIB1. The UE can get synchronization and system information from other carriers for such carrier(s).
  + Potential impact to other WGS
    - RAN2:
      * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 of SSB-less operation
      * Handling of transmissions of SIB1 if changes to SIB1 transmission cycle is changed.
      * System information enhancement to provide other carriers’ information and carrier selection principles for UE.
      * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.
      * For SIB-less carrier, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.
    - RAN3:
      * Cross carrier synchronization for single carrier operation.
      * , and the
    - RAN4:
      * feasibility of only on-demand SSB transmission for time/frequency synchronization.
      * RLM and RRM measurements from on-demand transmission of SSB.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #2-6F

* Technique #A-6 Adaptation of SSB/SIB1
  + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving.
  + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + Background:
    - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.
    - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.
    - For SSB/SIB-less operations, the carrier/cell is deployed without SSB/SIB1. The UE can system information from other carriers/cells for such carrier/cell(s) and synchronize either from other carriers/cells or from a simplified signals transmitted on the same carrier.
  + Potential impact to other WGS
    - RAN2:
      * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 from SSB/SIB1-less operation
      * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.
      * System information enhancement to provide other carriers’ information and carrier selection principles for UE.
      * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.
      * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.
    - RAN3:
    - RAN4:
      * feasibility of only on-demand SSB transmission for time/frequency synchronization.
      * RLM and RRM measurements from on-demand transmission of SSB.
      * network access performance requirements impacted by on-demand SSBs/SIB1.
      * measurement performance based on SSB

#### Proposal #2-6G

* Technique #A-6 Adaptation of SSB/SIB1
  + On-demand SSBs/SIB1 transmissions may also enable long periods of inactivity at the gNB to achieve gNB energy saving.
  + SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + Background:
    - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.
    - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.
    - The UE may obtain system information from other carriers/cells for such carrier/cell(s) and synchronize either from other carriers/cells or from a simplified signals transmitted on the same carrier.
  + Potential impact to other WGS
    - RAN2:
      * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1
      * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.
      * System information enhancement to provide other carriers’ information and carrier selection principles for UE.
      * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.
      * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.
    - RAN3:
    - RAN4:
      * feasibility of only on-demand SSB transmission for time/frequency synchronization.
      * RLM and RRM measurements from on-demand transmission of SSB.
      * network access performance requirements impacted by on-demand SSBs/SIB1.
      * measurement performance based on SSB

#### Proposal #2-6H

* Technique #A-6 Adaptation of SSB/SIB1
  + On-demand SSBs/SIB1 transmissions may also enable long periods of inactivity at the gNB to achieve gNB energy saving.
  + SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + Background:
    - Current specification supports SSB/SIB1-less operation for intra-band CA, where UE re-trieves system information and synchroniza-tion from another intra-band cell with SSB and SIB1.
  + Potential impact to other WGS
    - RAN2:
      * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1
      * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.
      * System information enhancement to provide other carriers’ information and carrier selection principles for UE.
      * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.
      * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell for inter-band CA case.
    - RAN3:
    - RAN4:
      * feasibility of only on-demand SSB transmission for time/frequency synchronization.
      * RLM and RRM measurements from on-demand transmission of SSB.
      * network access performance requirements impacted by on-demand SSBs/SIB1.
      * measurement performance based on SSB

#### Company Comments on Proposal #2-6E/F/G/H

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | Our comments are same as last round. |
| LG Electronics | For Title: We can add SIB1 as well.   * Technique #A-6 Adaptation of SSB/SIB1   For **main bullet**: Same as the previous round, “cell ON/OFF” can be removed since the term itself is unclear and chieve turning OFF the cell, gNB can operate with on-deman SSB/SIB1.   * + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving.   + For a serving cell with SSB/SIB1-less operation, SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.   For **“Background”**: For the first bullet, we fail to see the similarity between Rel-12 DRS and on-demand SSB/SIB1 here, so we would suggest to remove it. For the second bullet, we cannot assess which one is promising technique or not.   * + - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy. |
| Vivo | We suggest the following updates:   * + - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 from~~of~~ SSB-less operation       * Handling of transmissions of SIB1 if ~~changes to~~ SIB1 transmission cycle is changed.       * System information enhancement to provide other carriers’ information and carrier selection principles for UE.       * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.       * For SIB-less carrier, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.     - RAN3:       * Cross carrier synchronization for single carrier operation.   [vivo] what does this mean   * + - * ~~, and the~~     - RAN4:       * feasibility of only on-demand SSB transmission for time/frequency synchronization.       * RLM and RRM measurements from on-demand transmission of SSB. |
| ZTE, Sanechips | The adaptation of SSB doesn’t need to be bundled with cell on/off.   * Technique #A-6 Adaptation of SSB   + On-demand SSBs/SIB1 transmissions or SSB/SIB1-less operations may also enable long periods of inactivity at the gNB to achieve gNB energy saving ~~by the cell ON/OFF~~.   For the following bullet, we are not sure why DRX is considered.   * + Background:     - Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. ~~The DRX was introduced for cell in the OFF state to transmit in order for UE discovery.~~ The on-demand SSBs/SIB1 may be used ~~is~~ to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell enhancements.   Minor suggestions are as below.   * + - For SSB/SIB-less operations, the carrier/cell is deployed without SSB/SIB1. The UE can get synchronization and system information from other carriers/cells for such carrier(s)/cell(s).   + Potential impact to other WGS     - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 of SSB-less operation       * Handling of transmissions of SIB1 if ~~changes to~~ SIB1 transmission cycle is changed.       * System information enhancement to provide other carriers’ information and carrier selection principles for UE.       * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.       * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.   The synchronization requirement belongs to RAN4 impact, and has been reflected in the RAN4 bullets. It can be removed from RAN3 impact.   * + - RAN3:       * Cross carrier synchronization for single carrier operation. |
| Samsung | Reiterating our previous comments – 1) to avoid any assessment at this stage, e.g., in the background and 2) correct a typo:  ---------   * + Background:     - Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. The ~~DRX~~DRS was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell enhancements.     - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy~~; on-demand transmission of SSBs/SIB1 and SSB-less operations are promising way to get the benefits.~~   --------- |
| Fraunhofer | We suggest adding similar RAN4 impact as in Technique #A-1 due to the reducded availability of SSBs/SIB1 transmission.   * + - RAN4:       * The UE network access performance requirements in RAN4 might be impacted by on-demand SSBs/SIB1.       * The UE measurement performance based on SSB may be affected. |
| Huawei, HiSilicon | Same comments as LGE on:   * Adding SIB1 in title and removing Cell ON/OFF * And below,   + Potential impact to other WGS     - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 of SSB**/SIB1**-less operation |
| CEWiT | For an SSB less carrier the UE can achieve synchronization using some simplified DL signals transmitted on the SSB less carrier, hence we suggest to update the background as follows:   * + Background:     - Cell ON/OFF in Rel-12 LTE small cell enhacements works to enable the support of small cell ON/OFF. The DRX was introduced for cell in the OFF state to transmit in order for UE discovery. The on-demand SSBs/SIB1 is to support the UE discovery of the gNB in network energy saving state similar to Rel-12 small cell enhancements.     - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy; on-demand transmission of SSBs/SIB1 and SSB-less operations are promising way to get the benefits.     - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.   For SSB/SIB-less operations, the carrier is deployed without SSB/SIB1. The UE can get ~~synchronization and~~ system information from other carriers for such carrier(s) and synchronization either from other carriers or from a simplified signals transmitted on the same carrier. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Updated proposal to #2-5F based on comments. |
| ITRI | We are OK with FL’s proposal in principle. However, we think that we can focus on not to transmit/receive any signal during inactive duration in the very first step; and the limited transmission/reception during inactive duration may be further discussed. |
| QCOM6 | We prefer this proposal to focus on aspects of “on-demand SSB/SIB1” only since SSB/SIB-less operation can be discussed in frequency domain techniques. Furthermore, if the UE can access a cell with SSB/SI, it is not clear to us why the UE needs to get SI for the cell with SSB/SIB-less operation. More motivation for such scenarios is needed. Hence, we propose the following text update:   * + On-demand SSBs/SIB1 transmissions ~~or SSB/SIB1-less operations~~ may also enable long periods of inactivity at the gNB to achieve gNB energy saving.   + ~~For a serving cell with SSB/SIB1-less operation,~~ SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.   + Background:     - Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.     - For on-demand SSBs/SIB1 transmissions, UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.     - ~~For SSB/SIB-less operations, the carrier/cell is deployed without SSB/SIB1. The UE can system information from other carriers/cells for such carrier/cell(s) and synchronize either from other carriers/cells or from a simplified signals transmitted on the same carrier.~~   + Potential impact to other WGS     - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1 ~~from SSB/SIB1-less operation~~       * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.       * ~~System information enhancement to provide other carriers’ information and carrier selection principles for UE.~~       * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.       * ~~For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.~~ |
| Apple | We support QC’s suggestion to focus on on-demand SSB/SIB1 only. If we have on-demand SSB/SIB1, it is also questionable whether we can still call it SSB-less operation.  Otherwise, we would like some clarification on whether on-demand SSBs/SIB1 transmissions and SSB/SIB1-less operation are always used together here, and whether this is intended for a single-carrier operation only. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
| MediaTek | * On **Technique #A-6 Adaptation of SSB/SIB1**, the subbullets of “Background” look providing the description of the techniques instead of providing information of current specification. Regarding acquiring system information and synchronization from other cells, we would notice SSB/SIB-1 less operation has been supported for intra-band CA case, and potential RAN2 impact can focus on inter-band case. In this regard, we suggest the following revision:  |  | | --- | | * + On-demand SSBs/SIB1 transmissions may also enable long periods of inactivity at the gNB to achieve gNB energy saving.   + SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.   + The UE may obtain system information from other carriers/cells for such carrier/cell(s) and synchronize either from other carriers/cells or from a simplified signals transmitted on the same carrier.   + Background:     - ~~Reduced transmission of SSBs/SIB1 can enable gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.~~     - ~~For on-demand SSBs/SIB1 transmissions,  UE can trigger normal SSB/SIB1 in case SSB and SIB1 are needed.~~     - ~~The UE may obtain system information from other carriers/cells for such carrier/cell(s) and synchronize either from other carriers/cells or from a simplified signals transmitted on the same carrier~~     - Current specification supports SSB/SIB1-less operation for intra-band CA, where UE retrieves system information and synchronization from another intra-band cell with SSB and SIB1.   + Potential impact to other WGS     - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1       * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.       * System information enhancement to provide other carriers’ information and carrier selection principles for UE.       * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.       * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell for inter-band CA case. | |
| Moderator | Updated to Proposal #2-6H |
| LG Electronics | We don’t think the last bullet corresponds to inter-band CA case, so we suggest to remove it, as follows.   * + - RAN2:       * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1       * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.       * System information enhancement to provide other carriers’ information and carrier selection principles for UE.       * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.       * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell. |

#### Other Aspects (not part of agreement)

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1. The summary will be captured in the moderator summary for information.

##### Technique #A-1 Adaptation of common signals and channels

* + Potential specification impact:
    - UE behavior for network access, such as initial access, measurements, RRM, and mobility, when informed about adaptation of common signals and channels. There is need to relax UE requirements to accommodate longer access or failure report latency, lower measurement accuracy and higher handover failure rate, due to the reduced availability of common channel/signals.
    - Mechanism on how UE can be informed about adaptation of common signals and channels
    - For adapting periodicity/availability of uplink random access opportunities, specification impact includes provisioning of adaptable RACH opportunities for Rel-18 UEs and associated RACH procedure.
    - DL indication mechanisms to inform UE of adaptation of common signals and channels.
    - Impact to TTI of system information blocks in RAN2 is expected if longer periodicities of SSB or SIB1 are to be supported.
    - Impact to paging occasion and paging frame definition in RAN2 is expected if enhancements to paging are to be supported.
    - Enabling UEs to adapt to the varying periodicity or transmission pattern of the common signals or channels; e.g., specification enabling UEs to enhance initial access performance to counter the impact due to increased SSBs/SIB1 periodicity.
    - Mechanisms to indicate/trigger the adaptation of the periodicity and/or a transmission pattern of downlink common and broadcast signals, including assistance of DL indication from network, UL WUS sent from UE
    - Impact on UL RO
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The legacy UEs may not operate in the cell with this technique. Legacy UEs may not recognize the adaptation of common signal and channel; e.g., initial access of legacy UEs expecting 20 ms SSB periodicity might fail with an increased SSB periodicity.
    - The UE assumptions on the measurements on the SSB by legacy UE for initial access, RLM, and RRM for mobility may get impacted.
    - The potential UE transitions to out-of-sync state when the periodicity of SSB is longer than the minimum duration in RAN4, e.g., 160 ms.
    - For adapting periodicity/availability of uplink random access opportunities, there is no impact to legacy UEs.
    - Legacy UE’s behavior for cell detection, RRM and RLM measurements, and random access do not change. Network implementation may avoid potential impact on legacy UEs by employing adaptation properly.
    - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.
    - Cell measurement is related to SSB periodicity. If legacy UE cannot be indicated the change of serving/neighbor cell SSB periodicity (due to new adaptation mechanism), there is impact to measurement accuracy (if UE cannot detect the correct periodicity) or longer latency for measurement outcome or hand-over, which can cause mobility performance degradation to legacy UE.
    - Legacy UE determine paging/cell common PDCCH occasions based on SIB1 configuration. If a new adaptation mechanism other than SI update mechanism is introduced, it is possible legacy UE cannot be notified of the change, and PO and common PDCCH monitoring will be failed.
  + The following options are various methods of adaptation for Technique #A-1a.
    - Option 1) introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH, or PSS and SSS with partial PBCH
    - Option 2) Different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH
    - Option 3) Transmission occasion of one or more common signals/channels of specific periods can be skipped.
    - Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, more than one periodicity are expected to potentially provide longer inactivity periods for the gNB.
    - Option 5) Support of configuration of longer periodicity (than what is currently supported) of common signals and/or uplink random access opportunities
    - Option 5a) Provisioning of additional uplink random access opportunities for Rel-18 UEs.
    - Option 6) The varying periodicity and/or dynamically changing a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.
    - Option 7) Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly Ros can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.
    - Option 8) Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.
    - Option 9) Simplified DL signals in lieu of SSBs or prior to SSBs to improve the initial access performance significantly while letting the periodicity of transmission be large enough for NES, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.
    - Option 10) support of a long period (rather than the period as the same as the SSB period) of search space
    - Option 11) support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead

##### Technique #A-2: Dynamic adaptation of UE specific signals and channels

* + Potential specification impact:
    - gNB may enter into sleep mode for a period of time along with the indication of network energy saving or non enery saving state, e.g., in terms of start time and duration.
    - UE assistance information report
    - Dynamic signaling design to reduce transmission of these UE specific channels/signals, by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not able to use resources in all network energy saving states.
  + Reduction of time occasions or synchronization of UE specific signal/channels can be performed based on following options:
    - Option 1) RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
    - Option 2) UE specific, and group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals

##### Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)

* + Potential specification impact:
    - If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.
    - Uplink signal design & related procedure for waking up a gNB
    - WUS signal/channel design
    - Mechanism on how UE can be informed about WUS signal/resource
    - UE measurements of PL of the gNB in the NES state for the UL power setting of UL WUS
    - UE behavior/assumption after sending WUS
    - Conditions for triggering the request, e.g., DL synchronization
    - Signaling for the request
    - UE behavior after transmitting the request
    - Specification enabling UEs to obtain necessary DL synchronization and measurements prior to the WUS in the uplinkDesign of WUS transmitted by UE
    - Conditions for triggering WUS transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is assumed that UE is synchronized with the gNB in the NES state or the gNB in the NES state is provided with timing information for detection of WUS.
  + Additional aspects of waking up gNB
    - Option 1: UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring (i.e., cell off/inactive period), or with sparse SSB/SIB1 transmission and RACH monitoring (e.g. 160ms)
      * UE may send WUS when moving to the coverage of this energy saving cell or there is need for fast access/synchronization/measurement
      * The WUS may trigger gNB’s normal operation, i.e. normal SSB/SIB1 transmission and RACH monitoring (e.g. 20ms)
      * UE reads SSB/SIB1 and perform random access if applicable after transmitting WUS
    - Option 2: UE WUS is used to wake up a gNB in an energy saving state without reception of semi-static UL transmissions
      * Wake up signal (WUS) is triggerd by MAC layer.
      * UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
    - Support of assistance information such as mobility, location information from the UEs either directly or tought the anchor gNB intended to aid wake up operations by the gNBs.
    - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.
    - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - Wake up signal (WUS) is triggerd by MAC layer.
    - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.

##### Technique #A-4: Adaptation of DTX/DRX

* + DTX offset configuration at gNB
    - Offset value can be aligned with or close to SS burst location so as to minimize total BS active time for transmitting UE data and common channels/signals
  + DTX/DRX cycle configuration/pattern at the gNB
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the gNB.
    - Joint or separate configuration of DTX and DRX mode at the gNB is considered.
    - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.
    - cell-specific DTX/DRX operation may be different between Idle mode and connected mode
    - This may include association between WUS for gNB and the cell-specific DTX/DRX
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication
  + The technique may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced MAC CE and long DRX commend MAC CE. Cell-specific signaling can be based on paging PDCCH or paging early indication (DCI format 2\_7).
  + gNB sleep mode indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.
    - Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;
    - Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel
  + gNB sleep mode indication may include monitoring occasion for the next gNB state indication.
  + If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.
  + Potential specification impact:
    - when the network pauses transmission, common control channels as well as CSI-RS used for either mobility or for other purposes.Introduction of mechanism/signaling to enable inactive opportunity for gNB
    - Configuration and indication of gNB’s DTX/DRX information to UE
    - UE behavior/procedure when gNB’s DTX/DRX is in operation
    - Defining DTX/DRX pattern for gNB.
    - Mechanisms to align C-DRX configuration of UE, such as signaling design to align the C-DRX configuration.
    - Mechanism to wake up gNB from DTX/DRX
    - Configuration and indication of gNB’s DTX/DRX cycle information to UE
    - UE behavior/procedure when gNB’s DTX/DRX cycle is in operation
    - Design of DTX/DRX pattern
    - Adaptation of DTX/DRX by DL indication/WUS triggering
    - Impact on periodic signal/channel transmission
    - A set of cell-specific DRX configuration, including at least DRX offset value(s), in SIB
    - A mechanism of triggering adaptation for UE to align with the indicated cell-specific DRX configuration, e.g. DRX offset value
    - Configuration of DRX cycle aligned with the DTX/DRX cycle configuration/pattern used at the gNB for network energy saving
    - Dynamic L1/L2 indication to UE on the DTX mode/configuration applied at gNB and/or for switching to a DRX cycle corresponding to network energy saving
    - impact on preconfigured operations at the UE such as Harq codebook, SSB etc
      * UE transmit/receive by resuming the preconfigured operation upon gNB switching ON
    - Mechanism for indicating the network energy states in current or future time periods.
    - The technique may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
    - The technique may include group common signaling for the indication of adapted active/inactive state
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Impact from gNB DTX/DRX onto legacy UEs has to be assessed. Impact onto Rel. 18 idle/inactive UEs can be kept to zero if the gNB performs DTX outside of SSB/SI transmission instants. The same applies when gNB performs DRX outside the RO slots.
    - For, introduction of mechanism/signaling to enable inactive opportunity for gNB,
      * when it is done in a UE-specific manner(e.g. for connected mode Rel-18 UEs), no impact to legacy UEs.
      * when it is done in a legacy UE-transparent manner(e.g. for legacy UEs in idle and/or connected mode), no impact to legacy UEs.
    - N/A since if legacy UE’s DRX offset cannot be adjusted by the new adaptation mechanism, gNB is expected to reconfigure UE’s DRX setting or accommodate UE’s active time durationsLegacy UEs may incur longer access delays or unable to access the cell in some gNB inactive states.

##### Technique #A-6 Adaptation of common signals and channels

* + The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:
    - Option 1) DL signals to aid initial access and discovery of cells in lieu of SSBs.
    - Option 2) mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.
    - [Option 3] cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.]
      * [moderator note: Repeat of #3-1B?]
    - [Option 4] offloading SIB of the SIB-less cell to another cell. And SIB-less operation is for non-CA case.]
      * E.g., UE on SIB-less cell can obtain SIB via common channels transmitted on another cell.
      * [moderator note: Repeat of #3-1B?]
    - Option 5) Simplified DL signals in lieu of SSBs providing necessary synchronization prior to the UE trigger for on-demand SSBs/SIB1 and potentially enhancing initial access performance altogether significantly, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.
  + Potential specification impact:
    - On-demand SSB/SIB1 transmission or SSB/SIB1-less operation might have impact to the behavior of wUEs for network access, such as initial access, measurements, RRM, mobility, and so on.
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - Conditions and procedures on how UE sends on-demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - The UE assumptions and behavior of SSBs/SSB1 transmission for on-demand or no transmission of SSBs/SIB1 need to be specified
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Details of on-demand triggering, including the triggering signaling design, triggering signaling configuration, and the triggering procedure.
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Reduced or no availability of SSBs/SIB1 would result in performance degradation in terms of UE normal access to the network, such as initial access, measurements, RRM, mobility and so on.
    - Specification enabling UEs capable of performing initial access with on-demand SSBs/SIB1 transmission, e.g., defining simplified DL signals preceding a UE trigger to aid initial access and discovery of cells in lieu of regular SSBs
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - DL signaling mechanism that enable UE to synchronize with the gNB for sending the on demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - For on-demand SSB/SIB, the potential specification in RAN1 may include:
      * Uplink trigger signal design
      * Downlink signal/channel [which is to aid initial access and discovery of cells in lieu of SSBs] design, if supported.
      * SSB-less carriers operation is used for inter-band CA. Due to the fact that SSB-less carriers operation is already supported in intra-band CA, the existing procedure in RAN1 defined for intra-band case can be re-used in general.
      * For SIB-less carrier, there is no obviously specification impact in RAN1.
    - Signaling design for on-demand SSBs/SIB1 transmission indication, UE’s or network’s behavior in response to the on-demand indication, etc.
    - System information enhancement to provide other cell’s information and cell selection for UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The potential impact of RRM/RLM measurements and network access delay by UEs.
    - Impact on legacy UEs: legacy UEs might not recognize such a technique.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UE unable camp or perform initial access on cell with long periods of inactivity
    - Whether this technique is applicable to Connected, Inactive, or Idle mode

#### Company Comments on other aspects

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| --- | --- |
| Company | Comments |
| - | - |

### == Summary of 4th Round Discussions ==

The proposals are getting more stable. Here are the updates proposals for time domain techniques. Moderator suggests agreeing the following proposal.

#### Proposal #2-1G

* Technique #A-1 Adaptation of common signals and channels
  + Adapting the transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the transmission pattern/availability of uplink random access opportunities.
  + Background:
    - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels or reception of random-access signals may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.
    - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access resources.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.
      * The UE measurement performance based on SSB may be affected.

#### Proposal #2-2H

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting time occasions for the UE specific resources during periods of low activity.
    - Potential list of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - The semi-static configured UE specific channels/signals may require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more opportunities for gNB to enter inactive state.
    - Except for positioning RS (PRS), the configu-rations for the listed UE-specific sig-nals/chennels are BWP-specific, and BWP adaptation framework can be utilized for dy-namic adaptation
  + Potential impact to other WG
    - RAN2:
      * UE measurement procedure based on periodic CSI-RS
      * Configuration and procedures related to enhanced dynamic adaptation of one or more UE-specific signals/channels
    - RAN3:
    - RAN4:
      * Performance requirements of measurements based on periodic CSI-RS

#### Proposal #2-3G

* Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)
  + UE can send an uplink signal to request transitioning of a gNB inactive state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.
  + Can be used in support of other techniques. Exact design may depend on the supported technique.
  + Background:
    - With the support of WUS, the gNB might go to an inactive state (where it does not transmit nor receive signal/channel or where it only transmits and receives limited signals) outside of the WUS monitoring occasions. A gNB in an inactive state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.
  + Potential impact to other WG
    - RAN2:
      * Signaling details of wakeup configuration
      * Conditions to trigger WUS transmissions, and any WUS transmission related procedures and behaviors.
    - RAN3:
      * WUS configuration exchange across neighboring gNBs
      * Coordination on determination of gNB state across neighbor gNB that receive WUS
    - RAN4:
      * Feasibility of obtaining time/frequency synchronization and power setting for UEs that are sending WUS to the gNB that does not transmit SSB.

#### Proposal #2-4H

* Technique #A-4: Adaptation of DTX/DRX
  + With DTX/DRX, gNB has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, and may have no transmission/reception or only keep limited transmission/reception.
  + Enhancement of UE C-DRX where DRX cycles or offsets configured for UEs in connected mode or idle/inactive mode can be aligned, potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time.
  + gNB entering into inactive state for a period of time along with the possible indication of network adaptation of DTX/DRX.
  + Background:
    - In case of DTX/DRX the BS can go to inactive state with different time granularities. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its inactivity will be limited. The alignment of the DRX cycles or offsets for the UEs can be done only via RRC re-configuration. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - Since UE may monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.
  + Potential impact to other WGS
    - RAN2/RAN3:
      * gNB DTX/DRX patterns/parameters definition and potential gNB DTX/DRX patterns exchange across neighbor gNBs.
    - RAN4:

#### Proposal #2-6H

* Technique #A-6 Adaptation of SSB/SIB1
  + On-demand SSBs/SIB1 transmissions may also enable long periods of inactivity at the gNB to achieve gNB energy saving.
  + SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + The UE may obtain system information from other carriers/cells for such carrier/cell(s) and synchronize either from other carriers/cells or from a simplified signals transmitted on the same carrier.
  + Background:
    - Current specification supports SSB/SIB1-less operation for intra-band CA, where UE re-trieves system information and synchroniza-tion from another intra-band cell with SSB and SIB1.
  + Potential impact to other WGS
    - RAN2:
      * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1
      * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.
      * System information enhancement to provide other carriers’ information and carrier selection principles for UE.
      * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.
      * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell for inter-band CA case.
    - RAN3:
    - RAN4:
      * feasibility of only on-demand SSB transmission for time/frequency synchronization.
      * RLM and RRM measurements from on-demand transmission of SSB.
      * network access performance requirements impacted by on-demand SSBs/SIB1.
      * measurement performance based on SSB

## 2.3 Frequency-domain based Energy Saving Techniques

* [2] Huawei/HiSilicon
  + Observation 6: Use of SSB/SIB1 received from one carrier for other carriers in multi-carrier scenarios can bring considerable energy saving gain for network in low load cases.
  + Observation 7: Multi-carrier SIB-less operation does not have to be used with CA procedure for a UE. Instead, the SIB-less operation can bring significant latency reduction compared to the case where UE using carrier aggregation and handover procedures.
  + Proposal 4: Evaluate SIB1-less operation in multi-carrier scenario, where the SIB1 for one carrier with/without SSB/DRS with low-load is broadcasted on another carrier.
  + Observation 8: For SCell (de)activation, the UE can acquire time and frequency synchronization based on the reference signal, e.g. SSB, TRS and etc., on another CC to further reduce the BS energy and reduce the latency of fast SCell (de)activation.
  + Observation 9: The switching time produced by cell-specific BWP switch at network/gNB side cannot be used for any UE in the cell, resulting decreased spectrum efficiency.
  + Observation 10: Compared with the adaptation of scheduled PRBs in the same BWP, it is not clear how much further network power saving gain/benefit can be achieved by dynamic BWP bandwidth/PRBs adaptation (e.g. via BWP switching or dynamic bandwidth adaptation within a BWP).
* [3] Nokia, NSB
  + Observation-2: From the NW perspective, the dynamic BWP adaptation of UE(s) does not bring benefits to the NW side energy saving.
  + Observation-3: From the NW saving perspective, the benefits of group-common or cell-specific signaling for BWP adaptation operation could be minor if there is a limited number of UEs in the cell in a low-load scenario, which is the target of the Rel18 NW ES study as stated in the SID.
  + Observation-4: From the NW perspective, it is unclear for us on what is the benefits to the NW side energy saving by reducing the UE-side BWP adaptation/switching delay.
  + Observation-5: The NW energy saving gain is quite minor with dynamic adaptation of a resource grid in a carrier, due to NW/gNB running with FFT/iFFT of fixed size.
  + Proposal-7: Proponents provide further details on Technique #B-3, regarding dynamic adaptation of bandwidth of UEs within a BWP.
* [4] Spreadtrum Communications
  + Observation 4: The reduction of common signal/channel can be realized by SCell operations.
  + Observation 5: The dynamic cell on/off and the DTX can be realized by SCell operations.
  + Observation 6: Enabling load balance by bandwidth adaptation can provide the energy saving gain.
* [5] vivo
  + Proposal 6: Support lean Scell technique and capture the following in TR:
    - Technique description: Scell is operating without or with reduced transmission of SSB, SIB1 and/or paging while RACH transmission opportunity can still remain available in the Scell;
    - Performance analysis: This technique is beneficial for network energy saving compared to legacy multi-carrier case 1 and RACH load distribution in multiple carriers compared to legacy multi-carrier case 2;
    - Spec impact: It is needed to specify SSB-less transmission in inter-band CA case including synchronization, measurement and related requirement, offloading system information from one carrier to another carrier, RACH procedure involving anchor carrier and/or non-anchor carriers.
  + Proposal 7:The benefit and motivation of group-common Pcell change need to be clarified.
  + Proposal 8: The details and motivation of faster activation/deactivation of CC need to be clarified.
  + Proposal 9: The benefit of dynamic adaptation of UE operation bandwidth need to be clarified and evaluated.
* [6] China Mobile
  + Proposal 5:
    - The Scells without SSB in inter-band CA should be supported in Rel-18.
    - FFS: Which bands are feasible and the related UE requirements.
    - FFS: the details of mechanism.
* [7] OPPO
  + Proposal 5: Consider the following text proposal for TR 38.864.
    - Support of cell-group based Pcell switching for UEs in a going-to-sleep cell can be considered as it is efficient and beneficial to achieve energy saving gain.
* [8] CATT
  + Proposal 12: Dynamic bandwidth adaption for gNB energy saving could be considered in frequency domain.
  + Observation 11: SCell RF turning off operating would introduce additional SCell activation delay and RS overhead to allow UE synchronization and measurements.
  + Proposal 13: Dynamic and fast SCell ON/OFF and activation/deactivation should be studied for network energy saving.
  + Proposal 14: SSB-less transmission in Pcell should not be supported.
  + Proposal 15: If SSB enhancement for Scells in case of inter-band CA is considered, DL synchronization, AGC and QCL assumption performance should be ensured.
* [10] Intel
  + Observation 4: Intra-carrier bandwidth adaptation results in significant impact to maximum throughput, which has highly negative impact to total gNB activity time and power consumption. The reduction in power consumption from reduced bandwidth does not seem sufficiently large enough to overcome the loss in throughput and increase in active time duration.
  + Proposal 3: Based on evaluation finds, we suggest deprioritizing any potential enhancements (such as technique B-2 and B-3 from R1-2208185) related to intra-carrier bandwidth adaptation and related optimization.
* [11] Lenovo
  + Proposal 4: To support carrier bandwidth adaptation, study mechanisms for cell-specific resource grid bandwidth adaptation and UE-specific bandwidth adaptation within an active BWP.
  + Proposal 5: Include the following texts in TR38.864:
    - Technique #B-3: Dynamic bandwidth adaptation within a BWP and/or dynamic bandwidth adaptation of a resource grid of a cell
      * Network dynamically changes an active bandwidth of a BWP, and UE does not use resources outside the active bandwidth of the BWP.
      * Network dynamically changes an active bandwidth of a resource grid, and UE does not use resources outside the active bandwidth of the resource grid.
    - Analysis for technique #B-3:
      * For dynamic bandwidth adaptation within a BWP, a UE can perform fast bandwidth adaptation by operating with the maximum bandwidth of the BWP without using resources outside an active bandwidth of the BWP.
    - Spec impact for technique #B-3:
      * Configuration of multiple bandwidths for a BWP and dynamic indication of an active bandwidth of the BWP
      * Configuration of multiple bandwidths for a resource grid and dynamic indication of an active bandwidth of the resource grid
  + Proposal 6: For efficient SCell activation/deactivation management, cell activation request from UE and/or L1-based SCell activation/deactivation can be considered.
  + Proposal 7: Include the following texts in TR38.864:
    - Technique #B-1: Multi-carrier energy savings enhancements
      * UE sends a SCell activation request and monitors L1 indication for SCell activation/deactivation.
    - Analysis for technique #B-1:
      * UE request and L1 signaling enables fast SCell activation and deactivation.
    - Spec impact for technique #B-1:
      * Support of signal/channels for UE request and L1 indication
* [12] ZTE, Sanechips
  + SSB-less SCell or SSB-limited SCell is beneficial to network energy saving.
  + The SSB-less SCell scheme can obtain 5%~14.8% energy saving gain in the cases of RU=5%~25% for TDD and 9.4%~26.4% energy saving gain in the case of RU=5%~15% for FDD.
  + SSB-less SCell should be supported for inter-band CA.
  + The synchronization and TA issue of SSB-less SCell can be handled by NW implementation.
  + TRS is not needed for the SSB-less SCell at least in the case there is no DL traffic in the SCell.
  + Aperiodic TRS is triggered only when it is needed in the SCell activation process.
  + An uplink wake-up mechanism (WUS) can be considered to trigger on-demand RS/SSB transmission in SSB-less SCell
  + Capture the following description of SSB-less for inter-band CA in TR.
    - SSB-less SCell for inter-band CA implemented by configuring one or more SSB-less SCell for UEs.
    - Performance analysis
      * The SSB-less SCell scheme can obtain 5%~14.8% energy saving gain in the cases of RU=5%~25% for TDD and 9.4%~26.4% energy saving gain in the case of RU=5%~15% for FDD.
    - Specification impact may include
      * Uplink WUS to trigger on-demand RS to reduce the impact of SSB-less SCell on user experience.
      * Aperiodic TRS triggered by SCell activation.
* [14] CMCC
  + Observation 4: The power saving gain of dynamic cell specific or group common BWP adaption depends on implementation.
  + Observation 5: The absolute power saving gain of intra-band SSB-less depends on gNB implementation, at least the transmit power for such symbols on Scell can be reduced.
  + Proposal 14: Inter-band Scell with reduced SSB or SSB-less can be studied to reduce power consumption of gNB.
  + Observation 6: Fast activation/de-activation of Scell can be chieved along with intra-band/inter-band SSB-less Scell.
  + Proposal 15: DCI based Scell activation/de-activation can be introduced for intra-band /inter-band SSB-less Scell scenario.
  + Proposal 16: Mechanisms to trigger normal SSB/SIB1 on demand should be studied for inter-band Scell with reduced SSB/SIB1 scenario.
  + Proposal 17: Dynamic indicating of activated Scells can be studied to reduce gNB power consumption.
  + Proposal 18: Dynamic Pcell change can be studied to support fast carriers on/off.
  + Proposal 19: To realize offloading before RRC connected mode for common Pcell, initial access by Scell can be studied.
  + Proposal 20: Technique aspects related to frequency domain multi-carrier scenario are summarized as follows:
    - Technique #FD-1: Multi-carrier energy savings enhancements
      * Techniques description: Scells without or with reduced periodic signals and channels transmission such as SSB can provide power reduction gain.
        + Intra-band CA with SSB-less Scell is already supported, but can be additional enhanced for further power saving, such as fast activation/de-activation.
        + Inter-band CA with SSB-less or reduced SSB Scell.
      * Specification impact:
        + Fast activation/de-activation of Scell.
        + On-demand triggering of normal SSB for fast scheduling on Scell
        + Adaption of Pcell or monitored Scell for fast turning off carriers
        + Initial access from Scell to offload initial access pressure on Pcell
* [15] NEC
  + Proposal 4: enhancement on cell activation/deactivation and cell dormancy should be supported to better support gNB energy saving and minimize the impact on UE operation.
  + Proposal 5: support cell wake-up signal transmitted by UE to wake-up a cell from deep sleeping mode, and UE assistant information carried by the cell wake-up signal can be considered.
  + Proposal 6: Reduced CSI-RS density for frequency domain network energy saving should be considered.
  + Proposal 7: Support reduced bandwidth and default UE BWP for network energy saving mode, as well as autonomous BWP switching.
* [16] LGE
  + Observation: Legacy mechanisms such as SCell (de)activation, BWP switching, and SCell dormancy indication, can be reused for the purpose of network energy savings in frequency domain.
  + Proposal #11: Consider to enhance dormancy operation and indication methods for deactivating frequency domain resources (e.g., SCell (de)activation or BWP switching via group-common DCI or MAC CE) or for adjusting the bandwidth of a given BWP.
* [17] Mediatek
  + Observation 4: For CA use cases with higher data activity, disabling SSB and/or SIB1 for SCell achieves very limited energy saving gains, i.e., <8% for Cat 1 BS and < 1% for Cat 2 BS.
  + Proposal 4: Disabling SSB and/or SIB1 for SCell is NOT pursued for network energy saving.
  + Proposal 5: Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching is recommended for network energy saving
  + Proposal 6: Reducing the BW adaptation delays is NOT pursued for network energy saving due to the reduced UE support on applying BWP adaptation for network energy saving.
* [18] Apple
  + Technique #B-1: Multi-carrier energy savings enhancements
    - The gNB can achieve potential energy savings from operating Scells without or with reduced transmission and reception of periodic signals and channels such as SSB, SI, and CSI-RS for mobility measurements, PRACH, paging, etc.
      * This may include support of mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access if the SCell can not share synchronization with Pcell.
      * This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another for inter-band CA.
        + Note that intra-band CA cases are already supported by current specification.
      * ~~Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.~~
      * Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to study the feasibility, and if feasible, identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.
        + [Comment] if we are seriously considering this, we should send an LS to RAN4 for feasibility study. Otherwise, it would not be possible to include it in the future WI.
      * To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.
    - Common signaling to a group of the UEs of Pcell change
    - [Comment] This should be and is discussed in RAN2.
    - Ability to quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic RS, UE request, and L1 response or dynamically switch Pcell is expected to potentially provide energy savings at the network.
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
  + Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
    - Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching may lower signaling overhead and operational cost (e.g. signaling overhead) for adaptation of BWPs of UE(s) and potentially improve gNB power consumption.
    - Reducing the BW adaptation delays for Rel18 UEs
  + Technique #B-3: Dynamic adaptation of bandwidth of UE(s) within a BWP [and dynamic adaptation of a resource grid in a carrier]
    - Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP reduces the latency and lowers the signaling overhead.
* [19] Fraunhofer IIS, Fraunhofer HHI
  + Observation 5: Multi-carrier energy saving enhancements focusing on NES only on specific carriers can guarantee legacy UE support on other carriers dedicated for backward compatibility serving as a coverage and mobility layer.
  + Proposal 8: Include the following bullets to the description of Technique #B-1: Multi-carrier energy savings enhancements, in the TR:
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable
* [20] Rakuten
  + Proposal 3: Consider techniques to reduce common signals/channels in Scells.
* [21] Panasonic
  + Proposal 2: For frequency domain adaptation for network energy saving, cell common adaptation by enhancement of BWP framework should be further considered for better efficiency within the BWP adaptation framework, where the time domain adaptation and/or the beam adaptation can also be supported. For multi-carrier adaptation enhancement, more careful study is needed for clearer benefit due to possible larger specification impact.
* [22] Interdigital
  + Proposal 2: Capture the following in TR38.864 (changes from R1-2208185 indicated in red):

|  |
| --- |
| Frequency Domain Techniques   * Technique #B-1: Multi-carrier energy savings enhancements   + The gNB can achieve potential energy savings from operating Scells without or with reduced transmission and reception of periodic signals and channels such as SSB, SI, and CSI-RS for mobility measurements, PRACH, paging, etc.     - This may include support of mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access if the SCell, it can not share synchronization with Pcell.     - This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another for inter-band CA.     - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.     - Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.     - To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.   + Common signaling to a group of the UEs of Pcell change   + Ability to quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic RS, UE request, and L1 response or dynamically switch Pcell is expected to potentially provide energy savings at the network.   + Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.   + Specification impact includes impact on initial access procedures, including inter-cell-SIB acquisition, inter-cell synchronization, and random access. Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels * Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier   + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching may lower signaling overhead and operational cost (e.g. signaling overhead) for adaptation of BWPs of UE(s) and potentially improve gNB power consumption.   + Reducing the BW adaptation delays for Rel18 UEs   + Specification impacts may include configuration of BWP for network energy saving state and group-common signaling indicating switch to this BWP. * Technique #B-3: Dynamic adaptation of bandwidth of UE(s) within a BWP [and dynamic adaptation of a resource grid in a carrier]   + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP reduces the latency and lowers the signaling overhead. |

* [23] Samsung
  + Proposal 13: For supporting inter-band CA, RAN1 shall ask RAN4 to investigate at least the following requirements on the carriers to perform CA operation:
    - Synchronization requirement between carriers;
    - Frequency distance requirement between carriers;
    - Reception power difference between carriers;
    - QCL assumption requirement across carriers.
  + Proposal 14: Support a cell-specific and/or UE-Group-specific L1 signaling for cell switching ON/OFF and activation/deactivation.
  + Proposal 15: Support adaptation of BWP for UEs in a carrier, and further support SPS PDSCH reception/Type-2 CG PUSCH transmission without reactivation after the BWP switching.
  + Proposal 16: Consider the following changes to the TP for TR
    - Technique #B-1: Multi-carrier energy ~~savings~~saving enhancements
      * The gNB can achieve potential energy savings from operating Scells without or with reduced transmission and reception of periodic signals and channels such as SSB, ~~SI, and~~ CSI-RS for mobility measurements, PRACH~~, paging~~, etc.
        + This may include support of mechanism for UE to trigger normal SSB~~/SIB1~~ transmission on a SCell for fast access, if the SCell~~, it~~ can not share synchronization with Pcell.
        + This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another for inter-band CA.
        + ~~Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the~~ The inter-band CA cases are the focus, while the enhancements could be potentially applicable to the intra-band CA cases.
        + Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.
        + To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.
      * Common signaling to a group of the UEs of Pcell change
      * Ability ~~to quickly~~for quick activation and deactivation of CC, for example, based on on-demand RS, aperiodic RS, UE request, and L1 response or dynamically switch Pcell is expected to potentially provide energy savings at the network.
      * Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
      * Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching may lower signaling overhead and operational cost (e.g. signaling overhead) for adaptation of BWPs of UE(s) and potentially improve gNB power consumption.
      * ~~Reducing the BW adaptation delays for Rel18 UEs~~
      * Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission without reactivation after the BWP switching.
    - Technique #B-3: Dynamic adaptation of bandwidth of UE(s) within a BWP ~~[and dynamic adaptation of a resource grid in a carrier]~~
      * Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP reduces the latency and lowers the signaling overhead.
* [24] Ericsson
  + BW adaptation at the network can potentially save energy at both network and UE side.
  + Potential of reducing the BW adaptation delays for Rel18 UEs can be considered particularly for the case that BW switch does not entail any RF reconfiguration.
  + Study group-common or cell-specific BWP switching.
  + Study techniques which optimize reference signal transmissions over Scells in terms of network energy savings.
  + Techniques allowing on-demand transmission of RSs, e.g., TRS particularly over Scells should be considered.
* [25] NTT Docomo
  + Observation 1: The existing BWP switching can be used for dynamic TX/RX bandwidth adaptation for network energy saving, while it will lead to DL overhead and power consumption due to DCI indications required for each UE in a cell.
  + Proposal 4: Study group-common based BWP switching and group-common BWP for network energy saving techniques.
* [26] Qualcomm
  + Proposal 6: Capture in TR the following description for dynamic UE group specific Pcell switching.
    - In CA operation, the UE is configured with a set of secondary cells in addition to a primary cell. To reduce network power consumption, some secondary cells may be dynamically deactivated or put in a dormant state while a common primary cell may be dynamically configured for a group of connected mode UEs especially when the system load is not high.
    - Scell deactivation/dormancy can provide network energy savings. However, it negatively impacts UPT and coverage. For example, with Set 1 FR1 reference configuration and CA with 2 CCs, Scell deactivation shows 33% average network energy savings when 20 UEs are assumed in a cell. However, it shows 64Mbps for 25 UEs per cell (61% RU) and 210Mbps for 20Ues per cell (39% RU).
    - Specification impact may include dynamic indication of primary cell switch to a group of UEs.
  + Observation 5: SSB/SI can be transmitted at a long periodicity in Scell to reduce broadcast overhead and network power consumption.
  + Observation 6: A long SSB/SI periodicity together with R17 temporary RS should already provide reasonably low Scell activation latency.
  + Proposal 7: Capture in TR the following description for inter-band CA with SSB-less carriers.
    - For inter-band CA with SSB-less carriers, the UE is configured with a primary cell and one or multiple secondary cells that do not transmit SSB. The secondary cells are associated with the primary cell. In particular, the UE may receive or transmit a signal/channel from the secondary cells based on time, frequency and QCL information from the associated primary cell. The technique is applicable to FR1 only.
    - Impact study may include
      * reliability of the time/frequency/spatial information from one carrier with SSB to be used for SSB-less carrier
      * collocation requirements for secondary cells and associated primary cell,
      * band requirements for secondary cells and associated primary cell,
      * requirements on timing difference between secondary cells and associated primary cell
* [28] CEWiT
  + Observation 5: Dynamic adaptation of bandwidth causes deactivation of certain frequency resources assigned to a UE that leads to conflicts, unnecessary transmissions and needless monitoring.
  + Observation 7: Group-common signaling to a number of UEs to adapt the bandwidth of their chievedding active BWPs and continue operating in same BWPs reduces the latency and lowers the signaling overhead.
  + Proposal 7: gNB signaling information about dynamic adaptation of BW to the active UEs is supported
    - Adapting the bandwidth of active BWP of a UE based on signalling from gNB is supported.

### [CLOSED] 1st Round Discussions

Companies should start thinking about what potential techniques to capture and what information would be captured together with the techniques. Moderator suggests refining the technique description further based on what was discussed in RAN1 #110. Discussion should include any suggestions to splitting or merging the techniques listed.

Please comment further on the following proposals, including comments to address notes from the moderator below.

#### Proposal #3-1

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-1: Multi-carrier energy savings enhancements
  + operating Scells without or with reduced transmission and reception of periodic(1) signals and channels such as SSB, SI, and CSI-RS for mobility measurements, PRACH, paging, etc.
    - This may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access if the SCell, it cannot share synchronization with Pcell.
    - This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another for inter-band CA.
    - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus. (2)
    - Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.(3)
    - To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.
  + Common signaling to a group of the UEs of Pcell change
  + Ability to quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic RS, UE request, and L1 response .
  + Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.(4)

Notes from the moderator on above:

* Note (1) Need to Clarify (enough to be able to be evaluated by companies)
  + Unlike single carrier only case, if this is for CA, the SCell with reduced transmission/reception of the mentioned channels is supported by existing specifications.
  + If this is for CA, then SCell without SSB/SIB is also supported by existing specifications at least for some cases.
* Note (2) Need to Clarify (enough to be able to be evaluated by companies)
  + Modifications may be preferred as it is not “in case” – it is the case that already supported.
* Note (3)
  + Technique aspect should include generally 3 parts: techniques description (with potential need of UE assistance), perform analysis (to be complete after evaluations, potentially including impact on UE side), specification impact (may also include need of UE assistance information that may have RAN2 impact, and can be updated/iterated in next meetings) – in addition to the “impacts on network interfaces” that is agreed from RAN3 last RAN3 meeting, when applicable.
* Note (4)
  + belong to performance/impact analysis

#### Company Comments on Proposal #3-1

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | As to the first note, we think the difference lies in SSB transmission on Scell can be adapted base on UE trigger or UE traffic.  For the second note, there are enhancement for both intra-band and inter-band SSB-less solution.When UE can get synchronization from other carriers, fast activation/de-activation of Scell can be chieved along with intra-band/inter-band SSB-less Scell. Of the three time parts that make up Scell activation procedure, the Tactivation time can be largely reduced due to synchronization to Pcell or other activated cell. And if DCI based activation or de-activation is further introduced, the THARQ part can also be reduced. With fast activation/de-activation of Scell, the UPT can be increased, and gNB can achieve power saving due to short transmission time duration.  This can be reflected in the second to last sub-bullet.  So we propose the following modification,   * + Ability to quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic RS, UE request, and L1 response and L1 activation command.. |
| vivo | For Note (1), only intra-band Scell without SSB transmission is supported in existing specifications. Inter-band Scell without SSB transmission is not supported. Besides, offloading SIB from Scell to Pcell is not supported in both intra-band and inter-band CA case. |
| Nokia/NSB | Based on our understanding from the Tdoc reading from companies, we have the following summary proposal for the Technique #B-1.   * Technique #B-1: Multi-carrier energy savings enhancements   Operating Scells without or with reduced transmission and reception of periodic signals and channels such as SSB   * Background: Intra-band SSB-less Scell operation has already been supported by the current specification, and it can be considered as the starting point for the study. * For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC for ES CC, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc * For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC cannot be performed for ES CC, there may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC. * For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, SIB1 of Scell can be delivered either jointly with SIB1 of anchor CC (Pcell) in the same time occasion, or be delivered separately in anchor CC (Pcell) in a different time occasions. * For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, in order to balance the load among CCs, the UE may perform random access in ES CC, even there is no SSB&SIB1 transmissions in ES CC, meaning that the SSB&SIB1 of ES CC is carried via anchor CC.   On (de-)activation of Scell   * Background: The Rel17 MR-DC enhancement can be considered as the starting point, where at Scell activation, a new MAC-CE from gNB provided up to two bursts of (temporary/aperiodic) CSI-RS to eliminate the need for the UE to wait for the scheduling of SSBs to perform time/frequency synchronization. At least for known SCell, the temporary RS method reduces the latency of transition from deactivated state to activated state. For unknown Scell, UE still relies on Rel-15 solution with SSBs. * Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing * Scell activation via UE sending request signal or by UE sending WUS signal   Regarding the red-font, we need more information from the proponents on how exactly it looks like and also corresponding spec. impact. |
| LG Electronics | Note (1): If multi-carrier operation (from UE perspective) is separated out from Technique #A-1, we suggest to modify Technique #B-1 as follows, to include variable periodicity or simplified version of SSB for SCell operation.   * + operating Scells without or with reduced transmission and reception of periodic(1) signals and channels such as SSB, ~~SI,~~ and CSI-RS for mobility measurements, PRACH, ~~paging,~~ etc.     - This may include mechanism for UE to trigger normal SSB~~/SIB1~~ transmission on a SCell for fast access if the SCell, it cannot share synchronization with Pcell.     - This may include flexibly varying the periodicity and/or a transmission pattern (when applicable) of SSB, and/or the periodicity of uplink random access opportunities.     - This may include introducing simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.   We have a clarification question for the highlighted part below. From UE perspective, system information will be received from Pcell but not from SCell. Therefore, SI offloading should be described in Technique #A-variant.   * + - This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another for inter-band CA.   We also have a clarification question for the highlighted part below. In our understanding, a SCell does not transmit SSB, UE can acquire time/freq sync. from other cell for which SSB is transmitted. If this is the case, yellow part may not be necessary.   * + - To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.   In addition, we suggest to add the following bullets under Technique#B-1.   * + UE group-common signaling to (de)activate SCell(s)   + Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP |
| ZTE, Sanechips | The following bullet seems unnecessary for the technique description. It is more likely to be a note of the second bullet. If it is needed, we can keep it as a sub-bullet of the second bullet for detailed clarification.   * + - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus. (2)   For the following bullets, the system information in the SCell is also not needed based on the current specification. Some suggestions are as below.   * + - This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA.     - This may include ~~and~~ support offloading system information from one cell to another for inter-band CA.   The following solutions don’t need to be supported at the same time. Minor suggestions are as below.   * + ~~Ability to~~ quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic UL/DL RS, UE request, and/or L1 response .   The following bullets are not technique descriptions, which can be considered in the spec impact, or other descriptions.   * + - Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.(3)   + Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.(4) |
| Fraunhofer | We propose include the following bullet:   * Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable |
| Samsung | * “SI” and “paging” should be removed from the first bullet, since they are not applicable to current Scell implementation and not consistent with the wording “without or with reduced transmission and reception”. If companies are considering supporting SI and paging for Scell for synchronization purpose, it should be a separate sub-bullet, instead of mixing with currently supported signals and channels for Scell. * The reasoning for “This may include support of mechanism for UE to trigger normal SSB/SIB1 transmission on a Scell for fast access if the Scell, it cannot share synchronization with PCell.” Should be justified. If a Scell cannot get synchronization directly from a PCell, how transmitting system information can help to get synchronization? The pre-condition of decoding system information is synchronization, but not the reversed. * Note 2: “Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.” Intra-band CA is indeed supported (Section 8.3.2 of TS 38.133), and we can clarify to focus on inter-band CA only. * Note 4: agree with FL.   We suggest the following update highlight yellow. Proposal #3-1  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #B-1: Multi-carrier energy saving~~s~~ enhancements   + operating Scells without or with reduced transmission and reception of periodic(1) signals and channels such as SSB, ~~SI, and~~ CSI-RS for mobility measurements, PRACH, ~~paging,~~ etc.     - This may include mechanism for UE to trigger normal SSB~~/SIB1~~ transmission on a SCell for fast access, if the SCell~~, it~~ cannot share synchronization with Pcell.     - This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another for inter-band CA.     - ~~Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the~~ The inter-band CA cases are the focus, while the enhancements could be potentially applicable to the intra-band CA cases. (2) |
| Intel | We think Note (2) provides answer to Note (1), that the inter-band CA case is the focus. Note (3) is generally applicable to techniques in different sections, so we include this proposal in Section 2.1.  Impact to HW architectures according to Note (4) may fall under qualitative analysis of impact for a certain technique. To this end, see our proposal in Section 2.1. |
| Apple | Note (2): suggest removing this paragraph and replace it with the sentence “”intra-band CA cases are already supported by current specification”.  On the intra-band CA case, we think it is important to emphasize that RAN4 investigation on feasibility is required before we can pursue with it in the WI. We think at least the feasibility study should be done in the study item phase if there is strong interest. |
| CATT | We are generally OK with the text descriptions as the placeholder. The general assumption, procedure and delay of fast activation/deactivation of SCell should be clearly described along with evaluation results. |
| InterDigital | We suggest capturing the specification impacts of Technique#B-1 and impacts to legacy UEs in Proposal #3-1 as follows:   * Specification impact includes impact on initial access procedures, including inter-cell-SIB acquisition, inter-cell synchronization, and random access. * Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels |
| Ericsson1 | Suggest using “cells” instead of “Scells” since there is no SI, paging on SCell (also OK with Scells, but then SIB1/paging has to be removed).  Also, suggest clarifying that the offloading system information is from one cell to another – interband CA suggests UE with traditional carrier aggregation, i.e. with a Pcell and Scells, but the intention seems a bit different here.  Our suggested updates are as follows:   * + operating cells without or with reduced transmission and reception of periodic(1) signals and channels such as SSB, SI, and CSI-RS for mobility measurements, CSI-RS for tracking, PRACH, paging, etc.     - This may include mechanism for UE to trigger normal SSB[/SIB1] transmission on a SCell for fast access if the SCell, it cannot share synchronization with Pcell.     - This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another cell, where the cells can be in different bands.     - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus. (2)     - Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.(3)     - To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.   + UE-specific signaling/Common signaling to a group of the UEs of Pcell change   + Ability to quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic RS, UE request, and L1 response .   + Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.(4) |
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#### Proposal #3-2

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Reducing the BW adaptation delays for Rel18 UEs

#### Company Comments on Proposal #3-2

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| Company | Comments |
| vivo | The application scenario of switching to an energy saving BWP is low load that means small number of UEs in the cell. The signaling overhead of UE specific BWP switching is not much. The benefit of group common BWP configuration and/or switching should be justified by further evaluations.  Besides, what’s the benefit of reducing BW adaptation delays for network energy saving? |
| Nokia/NSB | And as stated in our contribution, the truly network side energy saving gain with Technique #B-2 are not clear for us. We suggest the proponents to provide the evaluation justification. Otherwise, it hard to evaluate the benefits and make a decision to include such in the TR. |
| Huawei, HiSilicon | For Technique B-1, we think it should be further divided for clearly description of SSB-less and SIB1-less operation.   * Technique #B-1: Multi-carrier energy savings enhancements   + operating Scells without ~~or with reduced~~ transmission and reception of SSB ,~~SI,~~ and CSI-RS for mobility measurements, PRACH, paging, etc.     - This may include mechanism for UE to trigger normal SSB~~/SIB1~~ transmission on a SCell for fast access if the SCell, it cannot share synchronization with Pcell.     - This may include leveraging ~~SSB-less cell operations and~~ potential enhancements for SSB-less Scells, e.g. ~~support SSB-less cell operation for inter-band CA, and~~ support offloading system information from one cell to another for inter-band CA.     - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus. (2)     - Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.(3)     - To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.   + operating ~~S~~cells without ~~or with reduced~~ transmission ~~and reception~~ of ~~SSB,~~ SIB1~~, and CSI-RS for mobility measurements, PRACH, paging, etc~~.     - Note: This is for for non-CA case.     - This may include mechanism for UE to trigger normal ~~SSB/~~SIB~~1~~ transmission on a SCell for fast access if the SCell, it cannot share synchronization with Pcell.     - Simplified version of SSB can replace SSB for transmission on SIB-less carrier.     - This may include ~~leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support~~ offloading system information from one cell to another cell ~~for inter-band CA~~.   + Common signaling to a group of the UEs of Pcell change   + Ability to quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic RS, UE request, and L1 response .   + Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.(4) |
| Samsung | * The potential impact from “Reducing the BW adaptation delays for Rel18 UEs” is unclear. There seems no notion of BW adaptation delay from BS perspective and no corresponding BS requirement. Better to remove this bullet.   We suggest the following update highlight yellow. Proposal #3-2  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier   + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.   + ~~Reducing the BW adaptation delays for Rel18 UEs~~   + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission without reactivation after the BWP switching. |
| Intel | While we do not have any specific comments about the potential technique. From our initial evaluations, we were not able to identify any power saving gains from reducing the gNB bandwidth even at very low loads. Reduction of the bandwidth already resulted in significant reduction in maximum throughput, and this negatively impacts the BS to stay active for longer periods. Therefore, reduction of bandwidth while may save some power for the slot that is being operational, actually results in more power consumed by the BS to service the traffic for longer periods of time.  We think careful evaluation of intra-carrier BW adaptation is needed before concluding that this can be a potential technique to save power. |
| CATT | We are OK with the text proposal. The network energy saving of dynamic BWP adaptation could be observed when aggregated traffic arrival has large variation. The BWP would be dynamically adapted to the variation of traffic arrival. |
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#### Proposal #3-3

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-3: Dynamic adaptation of bandwidth of UE(s) within a BWP [and dynamic adaptation of a resource grid in a carrier]
  + Enhancements to enable group-common signaling(5) to adapt the bandwidth of active BWP and continue operating in same BWP.

Notes from the moderator on above:

* Note (5) Need to Clarify (enough to be able to be evaluated by companies)
  + This could be the main bullets as replacement of “Dynamic adaptation of bandwidth of UE(s) within a BWP”, otherwise that part in main bullet is already supported by existing specifications.

#### Company Comments on Proposal #3-3

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| Company | Comments |
| Lenovo | Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation. |
| Vivo | The application scenario of BWP bandwidth adaptation is low load that means small number of UEs in the cell. The signaling overhead of UE specific BWP switching is not much. The benefit of group common BWP configuration and/or switching should be justified by further evaluations. |
| Nokia/NSB | And as stated in our contribution, we could like further clarification and evaluation justification from the proponents on this proposed technique. So far, it is not clear for us on what is the specification impact.  To the best of our knowledge, the NW/gNB could be running with FFT/iFFT of fixed size, where majority of the NW hardware components may not be switched-off at all when smaller number of allocated PRBs is used. Thus, the NW energy saving gain is quite limited in such case. |
| LG Electronics | Note (5): To differentiate from existing UE behavior, we can add the following bullet. In our understanding, based on adapted BW within a BWP, UE may not be required to monitor PDCCH corresponding to deactivated frequency resource, which seems not to be supported by existing specifications.   * + UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP. |
| Samsung | * We don’t see the benefit from “dynamic adaptation of a resource grid in a carrier”, and it may have huge specification impact since such resource grid is indicated by k\_SSB values. * The gain from dynamic adaptation on UE operation bandwidth within a BWP need to be justified, especially considering its relationship with dynamic FDRA, e.g., for PDSCH and PUSCH. The proposal is for signals and channels without dynamic FDRA, e.g., CSI-RS and PUCCH?   We suggest the following update highlight yellow. Proposal #3-3  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #B-3: Dynamic adaptation of bandwidth of UE(s) within a BWP ~~[and dynamic adaptation of a resource grid in a carrier]~~   + Enhancements to enable group-common signaling(5) to adapt the bandwidth of active BWP and continue operating in same BWP. |
| Intel | Similar to what we have commented for Proposal #3-2, we think careful evaluation of intra-carrier BW adaptation is needed before concluding that this can be a potential technique to save power.  It was not evident that reduction of bandwidth actually yields in better power consumption for the base station. |
| CEWiT | For Note (5), Currently the existing specifications support adaptation of UE BWP by BWP switching but doesnot support dynamic adaption of an active BWP, whereas this technique deals with variation of the BW of an active BWP, without the need for BWP switching. Thus, for more clarity we suggest following modification in the technique #B-3   * Technique #B-3: Dynamic adaptation of bandwidth of ~~UE(s) within a~~  an active BWP of UEs [and dynamic adaptation of a resource grid in a carrier]   + Enhancements to enable group-common signaling(5) to adapt the bandwidth of active BWP and continue operating in same BWP. |
| CATT | We have reservation on Proposal#3-3. The variation of TX BW in the same BWP with same IFFT does not have any change in gNB power consumption. We need to agree on the power scaling model for this issues first. |

### Summary of 1st Round Discussions

Based on feedback received moderator has updated the proposals as follows. Moderator suggest using the updated proposal for further discussions.

Notation of change marks above:

* Red Underline or ~~Stikethrough~~ Text: Updated text based on comments.
* Blue Underline Text: Updated text based on comments. However, moderator thinks further clarification is needed
* Green Text: Unchanged text. However, based on comments, moderator thinks further clarification is needed.

For Proposal 3-1, Nokia seems to have made a nice summary. Let’s see if Nokia’ summary seems ok to all.

Proposal #3-1A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-1: Multi-carrier energy savings enhancements
  + Operating cells ~~Scells~~ without or with reduced transmission and reception of periodic signals and channels such as SSB, ~~SI, and CSI-RS for mobility measurements, PRACH, paging, etc.~~
    - Background: Intra-band SSB-less Scell operation has already been supported by the current specification, and it can be considered as the starting point for the study.
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC for ES CC, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC cannot be performed for ES CC, there may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC.
    - For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, SIB1 of Scell can be delivered either jointly with SIB1 of anchor CC (Pcell) in the same time occasion, or be delivered separately in anchor CC (Pcell) in a different time occasions.
    - For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, in order to balance the load among CCs, the UE may perform random access in ES CC, even there is no SSB&SIB1 transmissions in ES CC, meaning that the SSB&SIB1 of ES CC is carried via anchor CC.
    - ~~This may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access if the SCell, it cannot share synchronization with Pcell.~~
    - ~~This may include leveraging SSB-less cell operations and potential enhancements for SSB-less cells, e.g. support SSB-less cell operation for inter-band CA, and support offloading system information from one cell to another for inter-band CA.~~
    - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.
    - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.
    - ~~Moreover, regarding cross carrier synchronization and measurement for inter-band CA cases, involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc.~~
    - ~~To facilitate leveraging of lean Scells, potential enhancements to provide time and frequency synchronization, and other measurement sources by another cell can be considered.~~
  + Additional aspects to be considered together with operation of Scells without or with reduced transmission of periodic transmission and reception are:
    - UE specific or UE group-common signaling to (de)activate SCell(s), and/or Pcell change
    - Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP
    - ~~Common signaling to a group of the UEs of Pcell change~~
    - ~~Ability to~~ quick~~ly~~ activation and deactivation of CC, for example, based on on-demand RS, aperiodic DL/UL RS, UE request, and L1 response and L1 activation command
  + On (de-)activation of Scell
    - Background: The Rel17 MR-DC enhancement can be considered as the starting point, where at Scell activation, a new MAC-CE from gNB provided up to two bursts of (temporary/aperiodic) CSI-RS to eliminate the need for the UE to wait for the scheduling of SSBs to perform time/frequency synchronization. At least for known SCell, the temporary RS method reduces the latency of transition from deactivated state to activated state. For unknown Scell, UE still relies on Rel-15 solution with SSBs.
    - Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing
    - Scell activation via UE sending request signal or by UE sending WUS signal
  + Potential specification impact:
    - Specification impact includes impact on initial access procedures, including inter-cell-SIB acquisition, inter-cell synchronization, and random access.
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
  + Additional considerations:
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.
    - RAN4 investigation on feasibility may be required.

It should be noted that few companies have questioned the actual power saving benefits of Proposal #3-2A.

Proposal #3-2A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + ~~Reducing the BW adaptation delays for Rel18 UEs~~
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission without reactivation after the BWP switching.
  + Potential specification impact:
    - FFS

It should be noted that few companies have questioned the actual power saving benefits of Proposal #3-3A.

Proposal #3-3A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs ~~UE(s) within a BWP~~ ~~[and dynamic adaptation of a resource grid in a carrier]~~ 
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Background: Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.
    - UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.
  + Potential specification impact:
    - FFS

#### Proposal #3-1A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-1: Multi-carrier energy savings enhancements
  + Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB
    - Background: Intra-band SSB-less Scell operation has already been supported by the current specification, and it can be considered as the starting point for the study.
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC for ES CC, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC cannot be performed for ES CC, there may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC.
    - For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, SIB1 of Scell can be delivered either jointly with SIB1 of anchor CC (Pcell) in the same time occasion, or be delivered separately in anchor CC (Pcell) in a different time occasions.
    - For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, in order to balance the load among CCs, the UE may perform random access in ES CC, even there is no SSB&SIB1 transmissions in ES CC, meaning that the SSB&SIB1 of ES CC is carried via anchor CC.
    - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.
    - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.
  + Additional aspects to be considered together with operation of Scells without or with reduced transmission of periodic transmission and reception are:
    - UE specific or UE group-common signaling to (de)activate SCell(s), and/or Pcell change
    - Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP
    - Quick activation and deactivation of CC, for example, based on on-demand RS, aperiodic DL/UL RS, UE request, and L1 response and L1 activation command
  + On (de-)activation of Scell
    - Background: The Rel17 MR-DC enhancement can be considered as the starting point, where at Scell activation, a new MAC-CE from gNB provided up to two bursts of (temporary/aperiodic) CSI-RS to eliminate the need for the UE to wait for the scheduling of SSBs to perform time/frequency synchronization. At least for known SCell, the temporary RS method reduces the latency of transition from deactivated state to activated state. For unknown Scell, UE still relies on Rel-15 solution with SSBs.
    - Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing
    - Scell activation via UE sending request signal or by UE sending WUS signal
  + Potential specification impact:
    - Specification impact includes impact on initial access procedures, including inter-cell-SIB acquisition, inter-cell synchronization, and random access.
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
  + Additional considerations:
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.
    - RAN4 investigation on feasibility may be required.

#### Proposal #3-2A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission without reactivation after the BWP switching.
  + Potential specification impact:
    - FFS

#### Proposal #3-3A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Background: Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.
    - UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.
  + Potential specification impact:
    - FFS

### [CLOSED] 2nd Round Discussions

Based on discussion from GTW, we should split the discussion into two components. First aspect is regarding high level descriptions of the potential techniques, their potential specification impact, any impact to legacy UEs. The second aspect is providing even further details targeting providing information for evaluations.

#### Proposal #3-1B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #B-1: Multi-carrier energy savings enhancements
  + Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB
    - Background: Intra-band SSB-less Scell operation has already been supported by the current specification, and it can be considered as the starting point for the study.
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC for ES CC, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC cannot be performed for ES CC, there may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC.
    - For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, SIB1 of Scell can be delivered either jointly with SIB1 of anchor CC (Pcell) in the same time occasion, or be delivered separately in anchor CC (Pcell) in a different time occasions.
    - For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, in order to balance the load among CCs, the UE may perform random access in ES CC, even there is no SSB&SIB1 transmissions in ES CC, meaning that the SSB&SIB1 of ES CC is carried via anchor CC.
    - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.
    - Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.
  + On (de-)activation of Scell
    - Background: The Rel17 MR-DC enhancement can be considered as the starting point, where at Scell activation, a new MAC-CE from gNB provided up to two bursts of (temporary/aperiodic) CSI-RS to eliminate the need for the UE to wait for the scheduling of SSBs to perform time/frequency synchronization. At least for known SCell, the temporary RS method reduces the latency of transition from deactivated state to activated state. For unknown Scell, UE still relies on Rel-15 solution with SSBs.
    - Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing
    - Scell activation via UE sending request signal or by UE sending WUS signal
  + Potential specification impact:
    - Specification impact includes impact on initial access procedures, including inter-cell-SIB acquisition, inter-cell synchronization, and random access.
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
  + Additional considerations:
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.
    - RAN4 investigation on feasibility may be required.
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #B-1: Multi-carrier energy savings enhancements
  + Additional aspects to be considered together with operation of Scells without or with reduced transmission of periodic transmission and reception are:
    - UE specific or UE group-common signaling to (de)activate SCell(s), and/or Pcell change
    - Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP
    - Quick activation and deactivation of CC, for example, based on on-demand RS, aperiodic DL/UL RS, UE request, and L1 response and L1 activation command

#### Company Comments on Proposal #3-1B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

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| --- | --- |
| Company | Comments |
| LG Electronics | We suggest to remove “anchor CC” or “ES CC” since the definition of them is unclear.  UE doesn’t care SIB1 transmission on SCell, so SIB1 related bullets can be removed.  Redudant bullet can be deleted.   * + Operating cells without or with reduced transmission and/or reception of periodic signals and channels such as SSB     - Background: Intra-band SSB-less Scell operation has already been supported by the current specification, and it can be considered as the starting point for the study.     - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc     - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell cannot be performed, there may include mechanism for UE to trigger normal SSB transmission on a SCell, where the on-demand or WUS type of uplink triggering signal can be transmitted at another serving cell.     - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.   In general, it is questionable we should capture the background of each technique. It would be better not to put our efforts on discussing how to capture NR techniques in previous releases.   * + On (de-)activation of Scell     - Background: The Rel17 MR-DC enhancement can be considered as the starting point.     - Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing     - Scell activation via UE sending request signal or by UE sending WUS signal     - UE group-common signaling to (de)activate SCell(s)   This technique is applicable to SCell, we are not sure if the following impacts on initial access or legacy UEs can be considered here.   * + Potential specification impact:     - Specification impact includes impact on RRM/CSI measurement and how UE can be informed about resource for on-demand or WUS type of uplink triggering signal |
| Spreadtrum | Like proposal #2-1B:   * + Potential specification impact:     - impact to the UEs network access, such as initial access, measurements, RRM, mobility, and so on.     - Mechanism on how UE can be informed about adaptation of common signals and channels   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - The legacy UEs may not operate in the cell with this technique. |
| Vivo | The high-level description needs to be simplified. We suggest the following change:   * + Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB     - Background: Intra-band SSB-less Scell operation has already been supported by the current specification, and it can be considered as the starting point for the study.     - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC.     - offloading SIB of the SIB-less cell to another cell. The SSB-less operation is used for inter-band CA case and SIB-less operation is for non-CA case     - Achieving RACH transmission opportunity in SSB/SIB-less Scell   The impact to legacy UEs should not be included in potential spec impact and suggest to remove “Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels”, i.e.   * + Potential specification impact:     - Specification impact includes impact on initial access procedures, including inter-cell-SIB acquisition, inter-cell synchronization, and random access. |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We prefer FL proposed wording. |
| QCOM2 | **On “Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB”**   * Agree with LGE on removing “anchor CC” or “ES CC”. * This discussion should just focus on Inter-band CA with SSB-less Scell * The discussion on SIB-less Scell is confusing and questionable. From UE perspective, if the SIB is already in the Pcell, why does the UE need to care whether SI is transmitted on Scell or not? We strongly ask the proponents to clarify the use cases and related UE behaviors.   Hence, below is our suggested update in red and green. Please also see the additional comments in the comment panel.   * + ~~Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB~~ Inter-band CA with SSB-less carriers     - Background: Intra-band SSB-less Scell operation has already been supported by the current specification~~, and it can be considered as the starting point for the study~~.     - Some Scells in Inter-band CA might not transmit SSB. T/F synchronization for the SSB-less Scell is based on the Pcell. This is targeting to some bands in FR1 only.     - Potential specification impact       * Clarify QCL source for receiving/transmitting channels especially when QCL source is related to SSB       * Mechanism to trigger SSB transmission or simplified SSB transmission in the SSB-less Scell (e.g., by using some uplink signal)     - Potential impact to other WGS       * RAN4 on ~~For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC for ES CC, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about~~ sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, applicable frequency band ~~QCL assumption requirement across carriers,~~ etc.     - ~~For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC cannot be performed for ES CC, there may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC.~~     - ~~For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, SIB1 of Scell can be delivered either jointly with SIB1 of anchor CC (Pcell) in the same time occasion, or be delivered separately in anchor CC (Pcell) in a different time occasions.~~     - ~~[Qualcomm commented: It is not clear on use cases of SIB-less Scell.]~~     - ~~For supporting of SSB&SIB1-less Scell operation for both Intra-band and Inter-band scenario, in order to balance the load among CCs, the UE may perform random access in ES CC, even there is no SSB&SIB1 transmissions in ES CC, meaning that the SSB&SIB1 of ES CC is carried via anchor CC.~~     - ~~Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.~~     - ~~Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.~~   **On (de-)activation of Scell**   * For unknow cells, the activation latency is not really due to whether the activation is done DCI or MAC-CE. It is mostly due to the cell measurement latency – Hence, temporary RS is introduced in R17 or inter-band CA with SSB-less is being considered in R18. * Skipping HARQ timing provide little reduction compared to the overall latency. We can discuss this later if proponents could provide performance in the next meeting. * “Scell activation via UE sending request signal or by UE sending WUS signal” – this fully overlaps with proposal for Technique A#3. We should discuss in under Technique A#3 proposal.   Hence, we suggest removing ON (de-)activation of Scell from the proposal.   * + ~~On (de-)activation of Scell~~     - ~~Background: The Rel17 MR-DC enhancement can be considered as the starting point, where at Scell activation, a new MAC-CE from gNB provided up to two bursts of (temporary/aperiodic) CSI-RS to eliminate the need for the UE to wait for the scheduling of SSBs to perform time/frequency synchronization. At least for known SCell, the temporary RS method reduces the latency of transition from deactivated state to activated state. For unknown Scell, UE still relies on Rel-15 solution with SSBs.~~     - ~~Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing~~     - ~~Scell activation via UE sending request signal or by UE sending WUS signal~~   **Missing technique**  One technique that the proposal has not captured is on UE-group Pcell switching. Hence, we propose to add the following to the proposal:   * Dynamic UE-group Pcell switching   + In multi-carrier operation, the UE may be configured with a set of secondary cells in addition to a primary cell. Note that a cell can be primary cell for a UE but can be secondary cell for another UE. To reduce network power consumption, a common primary cell may be dynamically configured for a group of UEs.   + Potential specification impact     - L1/L2 signalling to indicate primary cell change to a group of UEs |
| Ericsson2 | Suggest below updates (in red).  For potential specification impact, we suggest adding below.   * Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB at the gNB, might have impact to the UE normal access to the network, such as measurements, RRM and mobility.   Also, the following text should be placed under “Additional considerations.   * ” “*Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels*” |
| Lenovo | We suggest the following modifications:   * + Potential specification impact:     - Specification impact includes impact on initial access procedures, including inter-cell-SIB acquisition, inter-cell synchronization, and random access.     - Signals/channels for UE request and L1 indication in L1 based SCell activation/deactivation     - ~~Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels~~   + Additional considerations:     - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.     - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.     - RAN4 investigation on feasibility may be required.     - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels |
| DOCOMO | Agree with LGE/QC on removing “anchor CC” or “ES CC”.  Besides, the following text should be placed under “Potential impact to other WGs”.  *Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc* |
| Intel | Suggest to remove impact to legacy UE from specification impact and capture it into additional aspects/considerations  For impact to other WGs, the following should be added   * For inter-band SSB-less operation, feasibility input from RAN4 may be needed. * Configuration (including activation and deactivation) and sharing of information between cells for inter-carrier operation may require input from RAN2. |
| Apple | We agree with other companies that the description needs to be simplified. We largely support QC’s version on “Inter-band CA with SSB-less carriers”.  We also think RAN4 investigation on feasibility is required. The feasibility is a critical factor to determine whether this may be included in the future WI. So it makes sense to send an LS to RAN4 to study the feasibility. |
| Samsung | Only the first level details under the proposal are needed, and the sub-sub-bullets can all be outside the agreement.  Suggestions for the wording change:   * The wording “Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB…” itself is contradicting. We understand the intention, but if it goes to part of the agreement, it’s better to be clear. * In “a new MAC-CE from gNB provided up to two bursts of (temporary/aperiodic) CSI-RS”, “provided” is a confusing wording, and we believe it intended to say “triggers”. Also, the term “temporary RS” or “aperiodic CSI-RS” were used in MR DC discussion, but there is not concept of temporary CSI-RS. So we suggest to be changed to “a new MAC-CE from gNB triggers up to two bursts of aperiodic CSI-RS” * The wording “saving HARQ timing” is confusing in “Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing”. Does it intend to say “to save HARQ delay”? * Are “request signal” same as “WUS signal” in “Scell activation via UE sending request signal or by UE sending WUS signal”? * The first two bullets in “additional considerations” may not be needed, and RAN1 impact is not expected. |
| CMCC | We are fine with the two main sub-bullets, one is reduced SSB on Scell, and the other one is Scell (de)activation.  Some comments on the following bullet,   * + - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC for ES CC, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc       * Comment: Potential impact to other WGS     - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC cannot be performed for ES CC, there may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access/synchronization and measurement, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC.       * Comment: this seems to be potential specification impacts     - For supporting of SSB~~&SIB1~~-less Scell operation for both Intra-band and Inter-band scenario, SIB1 of Scell can be delivered either jointly with SIB1 of anchor CC (Pcell) in the same time occasion, or be delivered separately in anchor CC (Pcell) in a different time occasions.       * Comment: this seems to be potential specification impacts     - For supporting of SSB~~&SIB1~~-less Scell operation for both Intra-band and Inter-band scenario, in order to balance the load among CCs, the UE may perform random access in ES CC, even there is no SSB~~&SIB1~~ transmissions in ES CC, meaning that the SSB~~&SIB1~~ of ES CC is carried via anchor CC.       * Comment: this seems to be potential specification impacts     - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.       * Comment: this seems to be potential specification impacts   For the following sentence,   * + - Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) ~~by saving~~ to save HARQ timing |
| Fujitsu | We agree with QC’s proposal to add “dynamic UE-group Pcell switching” as a frequency-domain NW energy saving technique in multi-carrier operation. |
| ZTE, Sanechips | 1. Agree with LGE that it is better to change “anchor CC for ES CC” to “another serving cell”. 2. Agree with QC that for frequency domain, there is no SIB transmission from UE perspective, therefore, we think the frequency domain can focus on SSB-less SCell. For other common channel such as SIB, it can be time domain mechanism.  * Technique #B-1: Multi-carrier energy savings enhancements   + Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB     - SSB-less inter-band SCell: no SSB transmission in some inter-band SCell. The sync is acquired from PSCell, or another SCell without SSB.     - Background: Intra-band SSB-less Scell operation has already been supported by the current specification, and it can be considered as the starting point for the study.   [comments]the following bullet should be spec impact   * + - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC for ES CC, similar procedure as legacy Intra-band SSB-less Scell operation can be applied. Besides, the involvement of RAN4 WG is needed to identify necessary requirements ~~and guide for future RAN1 work~~, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc   [comments]the following bullets should be spec impact   * + - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via anchor CC cannot be performed for ES CC, there may include mechanism for UE to trigger ~~normal~~ SSB or other reference signal~~/SIB1~~ transmission on a SCell for fast SCell activation ~~access~~, where the on-demand or WUS type of uplink triggering signal can be received either at SCell without SSB or another serving cell ~~anchor CC or ES CC~~.     - .......     - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped, support of on-demand RS,.     - ~~Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus.~~   + Potential specification impact:     - Specification impact includes enhancements on SCell activation procedure.   + Additional considerations:   [comments]the following bullet can be incorporated into potential impact to other WGS   * + - RAN4 investigation on feasibility may be required. |
| MediaTek | On evaluations with CA, higher data rate/activity traffic, e.g., video, should be considered. Cell loading should also consider at least light load (15% - 30%) or medium load (30% - 50%). If the evaluation only considers low data rate traffic, e.g., IM, or low to empty load, it is not considered practically reflecting CA use case. |
| InterDigital | We are fine with the description under Proposal #3-1B and we suggest to move the description on legacy UE to under “Additional considerations” and include the following change:   * Additional considerations:   + UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.   + Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels |
| Nokia/NSB | Regarding the below bullet point:   * Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.   [Nokia/NSB]: Are there detailed description of the proposal, e.g. in which Tdoc that it is described. Specifically, about the “skipping”, is it the gNB behavior that skip the transmissions of PSS/SSS/PBCH, or it is the UE behavior that skip reception of the PSS/SSS/PBCH? We prefer more clarification here.  Regarding the below bullet point, probably we don’t need it anymore, since we have quite detailed descriptions in these bullet points above of it.   * ~~Currently both Intra-band CA and Inter-band CA scenarios are assumed. In case, the intra-band CA cases are already supported by current specification, then the inter-band CA cases are the focus~~. |

#### Proposal #3-2B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission without reactivation after the BWP switching.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + FFS

#### Company Comments on Proposal #3-2B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

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| Company | Comments |
| LG Electronics | We suggest background and potential specification impact, as follows. We also added SP-CSI reporting on PUSCH since it has a similar mechanism with SPS/CG type-2.   * + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.   + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission/SP-CSI reporting on PUSCH without reactivation after the BWP switching.   + Background:     - In Rel-17, UE-specific BWP configuration and switching is supported.     - For SPS PDSCH reception, type-2 CG PUSCH transmission, and SP-CSI reporting on PUSCH, once BWP is switched, they should be reactivated by activation DCI.   + Potential specification impact:     - Signalling details to support UE group-common or cell-specific BWP configuration and/or switching |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We are fine with the proposed wording with the suggestion in purple.   * Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier   + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.   + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission without reactivation after the BWP switching.   + Background:     - ~~[To be filled]~~ The reduction of RF BW had shown the reduction in energy consumption in LTE e-MTC. The dynamic adaptation of Tx BW of gNB RF by BWP switching in a cell could achieve network energy saving.   + Potential specification impact:     - ~~[To be filled]~~  Semi-static configuration of cell specific BWPs     - L1 signaling in cell specific BWP switching indication   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - ~~[To be filled]~~  The cell-specific BWP switching delay     - Interaction of cell-specific BWP switching and legacy UE-specific BWP switching.   + Potential impact to other WGS     - [To be filled] |
| DOCOMO | Fine with the updates on the potential specification impact proposed by LGE below.   * + Potential specification impact:     - Signalling details to support UE group-common or cell-specific BWP configuration and/or switching |
| Intel | Support LG’s addition to specification impact section. Prefer FL version for the rest  With that said, we would like to re-iterate our earlier comment that we have not observed any power saving benefits from intra-carrier BW adaptation. Therefore, we would like to further understand in which scenario and setup this is expected to provide power saving gains. |
| InterDigital | We are generally fine with the changes suggested by LGE. We suggest including the following addition for clarification:   * + Potential specification impact:     - Signalling details to support UE group-common or cell-specific ~~BWP~~ configuration and/or switching of BWP for network energy saving state |
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#### Proposal #3-3B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Background: Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.
    - UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.
  + Potential specification impact:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs
  + FFS

#### Company Comments on Proposal #3-3B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

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| Company | Comments |
| LG Electronics | We suggest some revision of background and specification impact.   * + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.     - Background: Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.   + Potential specification impact:     - Signalling details to support group-common or UE-specific bandwidth adaptation     - UE’s behavior that is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP. |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We don’t see the dynamic adaptation of Tx BW in terms of PRBs providing the network energy saving without change the RF BW. This has been well studied in LTE MTC and eMTC. |
| QCOM2 | * Technique #B-3: Dynamic adaptation of bandwidth of active BWP ~~of UEs~~   + Some frequency resources within the active BWP may be deactivated.   + ~~Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.~~     - Background: Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.     - ~~UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.~~   + Potential specification impact:     - Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.     - Introduce some frequency resource scheduling restriction within the active BWP.     - Clarify that UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP. |
| Lenovo | We suggest including the following:   * + Potential specification impact:     - Dynamic indication of an active bandwidth of an active BWP   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - No impact to legacy UE is expected, since network implementation can avoid any impact to legacy UE operation. |
| Intel | Similar to Proposal #3-2B, we have not observed any power saving benefits from intra-carrier BW adaptation. Therefore, we would like to further understand in which scenario and setup this is expected to provide power saving gains. |
| Apple | It is not clear to us the advantage of this over BWP switching. Some elaboration would be helpful. |
| CMCC | Is the BWP for adaption bandwidth a common BWP for UEs. If not, UEs have different active BWPs, and adapting the bandwidth of specific BWP for one UE may not saving gNB power. |
| CEWiT | We suggest some revision of background and specification impact.  Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs   * + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.     - Background: Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.     - UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.   + Potential specification impact:     - **Impacts on preconfigured operations (e.g. CSI-RS,configured grant, etc.) in deactivated portion of the active BWP**     - **Signalling mechanism for adaptation of active BWP**   Additional description intended to aid evaluations (not part of agreement)  **Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs**   * + **Signalling of deactivated portion (e.g., in terms of number of RBs and starting RB )** |

### Summary of 2nd Round Discussions

#### Proposal #3-1C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #B-1: Multi-carrier energy savings enhancements
  + Inter-band CA with SSB-less carriers
  + SSB-less inter-band SCell: no SSB transmission in some inter-band SCell. The sync is acquired from PSCell, or another SCell without SSB.
  + Background: Intra-band SSB-less Scell operation has already been supported by the current specification
    - * Description alternative 1)For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, similar procedure as legacy Intra-band SSB-less Scell operation can be applied.
    - Description alternative 2)
      * Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at anchor CC or ES CC.
      * Offloading SIB of the SIB-less cell to another cell. The SSB-less operation is used for inter-band CA case and SIB-less operation is for non-CA case
      * Achieving RACH transmission opportunity in SSB/SIB-less Scell
    - Description alternative 3)
      * Some Scells in Inter-band CA might not transmit SSB. T/F synchronization for the SSB-less Scell is based on the Pcell. This is targeting to some bands in FR1 only.
  + ~~On (de-)activation of Scell [Suggested to be deleted]~~
    - ~~Background: The Rel17 MR-DC enhancement can be considered as the starting point,~~
    - ~~Faster (de-)activation of Scell via DCI (instead of legacy MAC signaling) by saving HARQ timing~~
  + Dynamic UE-group Pcell switching
    - In multi-carrier operation, the UE may be configured with a set of secondary cells in addition to a primary cell. Note that a cell can be primary cell for a UE but can be secondary cell for another UE. To reduce network power consumption, a common primary cell may be dynamically configured for a group of UEs.
  + Potential specification impact:
    - Specification impact includes impact on RRM/CSI measurement and how UE can be informed about resource for on-demand or WUS type of uplink triggering signal
    - Clarify QCL source for receiving/transmitting channels especially when QCL source is related to SSB
    - Mechanism to trigger SSB transmission or simplified SSB transmission in the SSB-less Scell (e.g., by using some uplink signal)
    - L1/L2 signalling to indicate primary cell change to a group of UEs
    - Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB at the gNB, might have impact to the UE normal access to the network, such as measurements, RRM and mobility.
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell cannot be performed, there may include mechanism for UE to trigger normal SSB transmission on a SCell, where the on-demand or WUS type of uplink triggering signal can be transmitted at another serving cell.
    - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.
    - The legacy UEs may not operate in the cell with this technique
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Signals/channels for UE request and L1 indication in L1 based SCell activation/deactivation
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Specification impact includes enhancements on SCell activation procedure.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
  + Potential impact to other WGS
    - RAN4 investigation on feasibility may be required.
    - RAN4 on sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, applicable frequency band
    - involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc
    - For inter-band SSB-less operation, feasibility input from RAN4 may be needed.
    - Configuration (including activation and deactivation) and sharing of information between cells for inter-carrier operation may require input from RAN2.
    - Besides, the involvement of RAN4 WG is needed to identify necessary requirements and guide for future RAN1 work, i.e. about sync. requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumption requirement across carriers, etc

Additional description intended to aid evaluations (not part of agreement)

* Technique #B-1: Multi-carrier energy savings enhancements
  + Additional aspects to be considered together with operation of Scells without or with reduced transmission of periodic transmission and reception are:
    - UE specific or UE group-common signaling to (de)activate SCell(s), and/or Pcell change
    - Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP
    - Quick activation and deactivation of CC, for example, based on on-demand RS, aperiodic DL/UL RS, UE request, and L1 response and L1 activation command

#### Proposal #3-2C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission/SP-CSI reporting on PUSCH without reactivation after the BWP switching.
  + Background:
    - In Rel-17, UE-specific BWP configuration and switching is supported.
    - For SPS PDSCH reception, type-2 CG PUSCH transmission, and SP-CSI reporting on PUSCH, once BWP is switched, they should be reactivated by activation DCI.
  + The reduction of RF BW had shown the reduction in energy consumption in LTE e-MTC. The dynamic adaptation of Tx BW of gNB RF by BWP switching in a cell could achieve network energy saving.Potential specification impact:
    - Signalling details to support UE group-common or cell-specific BWP configuration and/or switching
    - Semi-static configuration of cell specific BWPs
    - L1 signaling in cell specific BWP switching indication
    - Signalling details to support UE group-common or cell-specific configuration and/or switching of BWP for network energy saving state
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The cell-specific BWP switching delay
    - Interaction of cell-specific BWP switching and legacy UE-specific BWP switching.
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + FFS

#### Proposal #3-3C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP
  + Some frequency resources within the active BWP may be deactivated.
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Background: Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.
  + Potential specification impact:
    - Signalling details to support group-common or UE-specific bandwidth adaptation
    - UE’s behavior that is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP
    - Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Introduce some frequency resource scheduling restriction within the active BWP.
    - Clarify that UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.
    - Dynamic indication of an active bandwidth of an active BWP
    - Impacts on preconfigured operations (e.g. CSI-RS,configured grant, etc.) in deactivated portion of the active BWP
    - Signalling mechanism for adaptation of active BWP
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - No impact to legacy UE is expected, since network implementation can avoid any impact to legacy UE operation.
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs

Signalling of deactivated portion (e.g., in terms of number of RBs and starting RB)

### [CLOSED] 3rd Round Discussions

Moderator suggests moving all “potential specification impact” and “Additional considerations/aspects (including any impact to legacy UEs, if any)” out of the initial agreement and to the additional information for now. The potential specification impact likely requires further edits and compressing duplicate information.

For the description to be agreed, moderator suggest focusing on the actual technique general description + background + potential impact to other WG

#### Proposal #3-1D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #B-1: Multi-carrier energy savings enhancements
  + Background:
    - Intra-band SSB-less Scell operation has already been supported by the current specification
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, similar procedure as legacy Intra-band SSB-less Scell operation may be applied.
  + Inter-band CA with SSB-less carriers
    - no SSB transmission in some inter-band SCell. The sync is acquired from PSCell, or another SCell without SSB.
    - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another carrier, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.
  + Dynamic UE-group Pcell switching
    - In multi-carrier operation, the UE may be configured with a set of secondary cells in addition to a primary cell. Note that a cell can be primary cell for a UE but can be secondary cell for another UE. To reduce network power consumption, a common primary cell may be dynamically configured for a group of UEs.
  + Potential impact to other WGS
    - RAN2:
      * Configuration (including activation and deactivation) and sharing of information between cells for inter-carrier operation.
    - RAN3:
    - RAN4:
      * investigation on feasibility.
      * synchronization requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumptions, and applicable frequency band
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #B-1: Multi-carrier energy savings enhancements
  + Potential specification impact:
    - Specification impact includes impact on RRM/CSI measurement and how UE can be informed about resource for on-demand or WUS type of uplink triggering signal
    - Clarify QCL source for receiving/transmitting channels especially when QCL source is related to SSB
    - Mechanism to trigger SSB transmission or simplified SSB transmission in the SSB-less Scell (e.g., by using some uplink signal)
    - L1/L2 signalling to indicate primary cell change to a group of UEs
    - Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB at the gNB, might have impact to the UE normal access to the network, such as measurements, RRM and mobility.
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell cannot be performed, there may include mechanism for UE to trigger normal SSB transmission on a SCell, where the on-demand or WUS type of uplink triggering signal can be transmitted at another serving cell.
    - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.
    - The legacy UEs may not operate in the cell with this technique
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Signals/channels for UE request and L1 indication in L1 based SCell activation/deactivation
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Specification impact includes enhancements on SCell activation procedure.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
  + Additional aspects to be considered together with operation of Scells without or with reduced transmission of periodic transmission and reception are:
    - UE specific or UE group-common signaling to (de)activate SCell(s), and/or Pcell change
    - Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP
    - Quick activation and deactivation of CC, for example, based on on-demand RS, aperiodic DL/UL RS, UE request, and L1 response and L1 activation command

#### Company Comments on Proposal #3-1D

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | The following paragraph can be general description of multi-carrier energy savings enhancements   * + The gNB can achieve potential energy savings from operating Scells without or with reduced transmission and reception of periodic signals and channels, such as SSB.   For the potential impact to other WGS part, if both of the two sub-bullets related to inter-band SSB-less, it can be stated clearly.   * + - RAN4:       * investigation on feasibility of inter-band SSB-less Scell.       * synchronization requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumptions, and applicable frequency band for inter-band SSB-less Scell operation. |
| Vivo | We suggest the following updates:   * + Inter-band CA with SSB-less carriers     - no SSB transmission in some inter-band SCell. The sync is acquired from PSCell, or another SCell ~~without SSB~~.     - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another carrier, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.   + Potential impact to other WGS     - RAN2:       * Configuration (including activation and deactivation) and sharing of information between cells for inter-carrier operation.       * RACH procedures in SSB/SIB-less Scell |
| CATT | We are OK with the proposal. However, we don’t agree with the Impact to RAN4.  RAN4 has the requirements of Time alignment error in 38.104 for single cell, intra-band CA, and inter-band CA. We don’t see additional requirements of synchronization between carrier are needed. |
| QCOM5 | We think “another Scell without SSB” seems wrong. For now, we can keep it general:   * + - no SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission ~~PSCell, or another SCell without SSB~~.   If a cell does not have SSB, SIB transmission does not seem necessary in the cell. In fact, SI in the cell with SSB (e.g., Pcell) should be sufficient:   * + - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger ~~normal~~ SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another carrier, ~~offloading SIB of the SIB-less cell to another cell~~, and supporting RACH transmission opportunity in SSB/SIB-less Scell.   The listed RAN4 impact is only for SSB-less carrier (not for dynamic UE-group Pcell switching), hence suggesting to make it clear:   * + - RAN4 for SSB-less carrier:       * investigation on feasibility.       * synchronization requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumptions, and applicable frequency band |
| Samsung | Agree with CMCC’s change. |
| DOCOMO | We are fine with CMCC’s update on potential WGs impact. |
| Ericsson3 | We propose below changes. Not clear why SIB1 is need for SCell. It is also unclear what is meant by “dynamically configured in ”*To reduce network power consumption, a common primary cell may be [dynamically configured] for a group of UEs.*   * Technique #B-1: Multi-carrier energy savings enhancements   + Background:     - Intra-band SSB-less Scell operation has already been supported by the current specification     - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation are to be studied.   + Inter-band CA with SSB-less carriers     - no SSB transmission in some inter-band SCell. The sync is acquired from PSCell, or another SCell without SSB.     - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another carrier, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.   + Dynamic UE-group Pcell switching     - In multi-carrier operation, the UE may be configured with a set of secondary cells in addition to a primary cell. Note that a cell can be primary cell for a UE but can be secondary cell for another UE. To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.   + Potential impact to other WGS     - RAN2:       * Configuration (including activation and deactivation) and sharing of information between cells for inter-carrier operation.     - RAN3:     - RAN4:       * investigation on feasibility.       * synchronization requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumptions, and applicable frequency band     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| ZTE, Sanechips | * + Background:     - Intra-band SSB-less Scell operation has already been supported by the current specification     - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, similar procedure as legacy Intra-band SSB-less Scell operation may be applied.   + Inter-band CA with SSB-less carriers/SCell     - no SSB transmission in some inter-band SCell. The sync is acquired from ~~PSCell~~SpCell, or another SCell without SSB.     - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another ~~carrier~~ cell, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell. |
| Huawei, HiSilicon | * Technique #B-1: Multi-carrier energy savings enhancements   + Inter-band CA with SSB-less carriers, or SIB transmission in non-CA     - no SSB transmission in some inter-band SCell. The sync is acquired from PSCell, or another SCell without SSB, also in order for fast activation and deactivation of SCell.     - No SIB transmission in a carrier that is not an SCell     - ~~Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB/SIB1 transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another carrier, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.~~   + Dynamic UE-group Pcell switching     - ~~In multi-carrier operation, the UE may be configured with a set of secondary cells in addition to a primary cell. Note that a cell can be primary cell for a UE but can be secondary cell for another UE. To reduce network power consumption,~~ a common primary cell may be dynamically configured for a group of UEs.   + Potential impact to other WGS     - RAN2:       * ~~Configuration (including activation and deactivation) and sharing of information between cells for inter-carrier operation.~~       * Cell search procedure and RACH procedure     - RAN4:       * ~~investigation on~~ feasibility.   + ~~synchronization requirement between carriers, frequency distance requirement between carriers, Rx power difference between carriers, QCL assumptions, and applicable frequency band~~ |

#### Proposal #3-2D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission/SP-CSI reporting on PUSCH without reactivation after the BWP switching.
  + Background:
    - In Rel-17, UE-specific BWP configuration and switching is supported.
    - For SPS PDSCH reception, type-2 CG PUSCH transmission, and SP-CSI reporting on PUSCH, once BWP is switched, they should be reactivated by activation DCI.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + The reduction of RF BW had shown the reduction in energy consumption in LTE e-MTC. The dynamic adaptation of Tx BW of gNB RF by BWP switching in a cell could achieve network energy saving.Potential specification impact:
    - Signalling details to support UE group-common or cell-specific BWP configuration and/or switching
    - Semi-static configuration of cell specific BWPs
    - L1 signaling in cell specific BWP switching indication
    - Signalling details to support UE group-common or cell-specific configuration and/or switching of BWP for network energy saving state
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The cell-specific BWP switching delay
    - Interaction of cell-specific BWP switching and legacy UE-specific BWP switching.

#### Company Comments on Proposal #3-2D

|  |  |
| --- | --- |
| Company | Comments |
| CATT | We are Ok with the proposal. |
| Samsung | OK with the proposal. |
| InterDigital | We suggest capturing the following under Proposal #2-2D:   * + Potential impact to other WGs     - RAN2:       * Impact on BWP switching procedure and configuration for UE group-common or cell-specific BWP. |
| DOCOMO | OK with the proposal. |

#### Proposal #3-3D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP. Some frequency resources within the active BWP may be deactivated.
  + Background:
    - Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs
  + Potential specification impact:
    - Signalling details to support group-common or UE-specific bandwidth adaptation
    - UE’s behavior that is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP
    - Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Introduce some frequency resource scheduling restriction within the active BWP.
    - Clarify that UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.
    - Dynamic indication of an active bandwidth of an active BWP
    - Impacts on preconfigured operations (e.g. CSI-RS,configured grant, etc.) in deactivated portion of the active BWP
    - Signalling mechanism for adaptation of active BWP
    - Signalling of deactivated portion (e.g., in terms of number of RBs and starting RB)
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - No impact to legacy UE is expected, since network implementation can avoid any impact to legacy UE operation.

#### Company Comments on Proposal #3-3D

|  |  |
| --- | --- |
| Company | Comments |
| CEWiT | We are fine with the proposal |
| CATT | We don’t agree to capture this proposal since the power saving of this proposal is for UE not gNB. There is no network energy saving when RF BW of gNB does not change. |
| Lenovo | OK with the proposal.  To clarify, this scheme is to accommodate gNB RF bandwidth reduction. UEs operating in a BWP affected by the gNB RF bandwidth reduction are informed that their active bandwidth of the BWP is reduced. |
| Samsung | OK with the proposal. |
| InterDigital | Considering simplified proposals for techniques #B-2 and #B-3, we suggest merging proposal #3-3D with #3-2D |

### [ACTIVE] 4th Round Discussions

#### Proposal #3-1E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #B-1: Multi-carrier energy savings enhancements
  + Background:
    - Intra-band SSB-less Scell operation has already been supported by the current specification
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.
  + Inter-band CA with SSB-less carriers/Scell or SIB transmission in non-CA
    - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission, also in order for fast activation and deactivation of SCell.
    - No SIB transmission in a carrier that is not an SCell.
    - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another carrier, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.
  + Dynamic UE-group Pcell switching
    - To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.
  + Potential impact to other WGS
    - RAN2:
      * RACH procedures in SSB/SIB-less Scell
    - RAN3:
    - RAN4:
      * Feasibility of inter-band SSB-less Scell
      * ~~Applicability of existing requirements for intra-band SSB-less Scell operation for requirements for inter-band SSB-less Scell operation~~
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #3-1F

* Technique #B-1: Multi-carrier energy savings enhancements
  + Background:
    - Intra-band SSB-less Scell operation has already been supported by the current specification
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.
  + Inter-band CA with SSB-less carriers/Scell
    - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission or same cell with simplified signal transmission, also in order for fast activation and deactivation of SCell.
    - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at inter-band SSB-less cell or another carrier/cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.
  + Dynamic UE-group Pcell switching
    - To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.
  + Potential impact to other WGS
    - RAN2:
      * RACH procedures in SSB-less Scell
      * System information, e.g. SIB1, enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.
    - RAN3:
    - RAN4:
      * Feasibility of inter-band SSB-less Scell

#### Proposal #3-1G

* Technique #B-1: Multi-carrier energy savings enhancements
  + Background:
    - Intra-band SSB-less Scell operation has already been supported by the current specification
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.
  + Inter-band CA with SSB-less carriers/Scell
    - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission or same cell with simplified signal transmission, also in order for fast activation and deactivation of SCell.
    - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand uplink triggering signal can be received either at inter-band SSB-less cell or another carrier/cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.
  + Dynamic UE-group Pcell switching
    - To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.
  + Potential impact to other WGS
    - RAN2:
      * For inter-band CA with SSB-less Scell:
        + RACH procedures in SSB-less Scell
        + System information, e.g. SIB1, enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.
    - RAN3:
    - RAN4:
      * Feasibility of inter-band SSB-less Scell

#### Proposal #3-1H

* Technique #B-1: Multi-carrier energy savings enhancements
  + Background:
    - Intra-band SSB-less Scell operation has already been supported by the current specification
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.
  + Inter-band CA with SSB-less carriers/Scell
    - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission or same cell with simplified signal transmission, also in order for fast activation and deactivation of SCell.
    - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand uplink triggering signal can be received either at inter-band SSB-less cell or another carrier/cell, and supporting RACH transmission opportunity in SSB -less Scell.
  + Dynamic UE-group Pcell switching
    - To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.
  + Potential impact to other WGS
    - RAN2:
      * For inter-band CA with SSB-less Scell:
        + RACH procedures in SSB-less Scell
      * Impact on procedure for dynamic Pcell switching
    - RAN3:
    - RAN4:
      * Feasibility of inter-band SSB-less Scell

#### Company Comments on Proposal #3-1E/F/G/H

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| Company | Comments |
| CMCC | We have noticed some discussion to move SSB/SIB-less in time domain to frequency domain.  We may need some common understanding that, the multi-carrier operation is seen from gNB perspective or from UE perspective.  SSB/SIB1-less can applied to a scenario where gNB has deployed multiple carriers, but UE works with a single carrier mode. And the UEs with non-CA can access to a carrier with SIB1-less or even SSB-less, SIB1 is carried by other carriers  SSB/SIB1-less can also applied to Scell of CA operation.  So if the common understanding is that both scenarios can be discussed in frequency domain, we are OK to move it here. |
| LG Electronics | **General aspect**: To our understanding, this Tech#B-1 for multi-carrier operation should be from UE perspective, i.e., SCell operation. Pcell operation is already covered by Tech#A-6.   * + Background:     - Intra-band SSB-less Scell operation has already been supported by the current specification     - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.   + Inter-band CA with SSB-less carriers/Scell     - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission, also in order for fast activation and deactivation of SCell.     - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received at another carrier, and supporting RACH transmission opportunity in SSB-less Scell.   + Dynamic UE-group Pcell switching     - To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.   + Potential impact to other WGS     - RAN2:       * RACH procedures in SSB-less Scell     - RAN3:     - RAN4:       * Feasibility of inter-band SSB-less Scell       * ~~Applicability of existing requirements for intra-band SSB-less Scell operation for requirements for inter-band SSB-less Scell operation~~ |
| vivo | We suggest the following updates with some inline comments:   * + Inter-band CA with SSB-less carriers/Scell or SIB transmission in non-CA     - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission, also in order for fast activation and deactivation of SCell.     - No SIB transmission in a carrier that is not an SCell.   [vivo] what does this mean   * + - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at the SSB-less carrier or at another carrier, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.   + Potential impact to other WGS     - RAN2:       * RACH procedures in SSB/SIB-less Scell       * Design of offloading SIB |
| ZTE, Sanechips | Minor suggestion as below.   * + - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at Inter-band SSB-less Scell or another carrier/cell, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell. |
| Samsung | “SIB transmission in non-CA” contradicts with the main bullet “multi-carrier”. It should be classified into another proposal with better matching. |
| Huawei, HiSilicon | @CMCC,  we appreciate your clarification and fine with either way. And we are aligned with your understanding.  @Samsung,  It was our fault – intends to be “SIB-less transmission in non-CA multi carrier”. While assuming it is also reflected in the RAN2 impact below, we could live with the wording, or further calrify it as you suggested.  To FL,   * + Potential impact to other WGS     - RAN2:       * RACH procedures in SSB/SIB-less Scell       * **System information, e.g. SIB1, enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell.** |
| CEWiT | For an SSB less carrier the UE can achieve synchronization using some simplified DL signals transmitted on the SSB less carrier, hence we suggest to update the proposal as follows:   * Technique #B-1: Multi-carrier energy savings enhancements   + Background:     - Intra-band SSB-less Scell operation has already been supported by the current specification     - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.   + Inter-band CA with SSB-less carriers/Scell or SIB transmission in non-CA     - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission or same cell with simplified signal transmission, also in order for fast activation and deactivation of SCell.     - No SIB transmission in a carrier that is not an SCell.   Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand or WUS type of uplink triggering signal can be received either at another carrier, offloading SIB of the SIB-less cell to another cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Updated the proposal to #3-1F based on comments. |
| ITRI | We are generally OK with FL’s proposal. However, we think that “no SIB transmission in a carrier that is not an SCell” should be further discussed. |
| QCOM6 | The following RAN2 impact is only applicable to SSB-less carrier. Hence, we suggest adding some clarification:   * + - RAN2: For inter-band CA with SSB-less Scell       * RACH procedures in SSB-less Scell       * System information, e.g. SIB1, enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell |
| Apple | We suggest deleting WUS from the following bullet for now. It can be just a generic description, and it can be any signal that serves the purpose. We do not really have a definition for WUS.   * + - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand uplink triggering signal can be received either at inter-band SSB-less cell or another carrier/cell, and supporting RACH transmission opportunity in SSB/SIB-less Scell.   On RAN2 impact, we suggest adding the following bullet for “dynamic UE-group Pcell switching”:   * + - * Impact on procedure for primary cell switching |
| Moderator | Updated |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
| LG Electronics | Two comments:   1. Since this technique focuses on SCell operation, SIB-related behavior needs to be removed. It should be noted that SIB-offloading is already covered by Technique#A-6 in our view. 2. As Apple commented, we agree that impact of PCell switching needs to be captured as RAN2 impact.    * Background:      + Intra-band SSB-less Scell operation has already been supported by the current specification      + For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.    * Inter-band CA with SSB-less carriers/Scell      + No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission or same cell with simplified signal transmission, also in order for fast activation and deactivation of SCell.      + Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand uplink triggering signal can be received either at inter-band SSB-less cell or another carrier/cell, and supporting RACH transmission opportunity in SSB-less Scell.    * Dynamic UE-group Pcell switching      + To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.    * Potential impact to other WGS      + RAN2:        - For inter-band CA with SSB-less Scell:          * RACH procedures in SSB-less Scell        - Impact on procedure for dynamic Pcell switching      + RAN3:      + RAN4:        - Feasibility of inter-band SSB-less Scell |
| Moderator | Updated in #3-1H |
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#### Proposal #3-2E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission/SP-CSI reporting on PUSCH without reactivation after the BWP switching.
  + Background:
    - In Rel-17, UE-specific BWP configuration and switching is supported.
    - For SPS PDSCH reception, type-2 CG PUSCH transmission, and SP-CSI reporting on PUSCH, once BWP is switched, they should be reactivated by activation DCI.
  + Potential impact to other WGS
    - RAN2:
      * Impact on BWP switching procedure and configuration for UE group-common or cell-specific BWP.
    - RAN3:
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #3-2F

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission/SP-CSI reporting on PUSCH without reactivation after the BWP switching.
  + Background:
    - In Rel-17, UE-specific BWP configuration and switching is supported.
    - For SPS PDSCH reception, type-2 CG PUSCH transmission, and SP-CSI reporting on PUSCH, once BWP is switched, they should be reactivated by activation DCI.
  + Potential impact to other WGS
    - RAN2:
      * Impact on BWP switching procedure and configuration for UE group-common or cell-specific BWP.
    - RAN3:
    - RAN4:

#### Company Comments on Proposal #3-2E/F

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| Company | Comments |
| LG Electronics | We are fine with Proposal #3-2E. |
| DOCOMO | We are fine with FL’s summary. |
| Samsung | OK with the proposal. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this. |
| ITRI | We are OK with FL’s proposal. |
| Apple | OK |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
|  |  |

#### Proposal #3-3E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP. Some frequency resources within the active BWP may be deactivated.
  + Background:
    - Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #3-3F

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP. Some frequency resources within the active BWP may be deactivated.
  + Background:
    - Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:

#### Company Comments on Proposal #3-3E/F

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| Company | Comments |
| LG Electronic | For “Background”: The last sentence can be removed since it seems to correspond to specification impact.   * + - Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. |
| Samsung | OK with the proposal. |
| Lenovo | We suggest the following modification:   * + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP. Some frequency resources within the active BWP may be deactivated. Both group-common signaling and UE-specific signaling can be considered for dynamic adaptation.   + Background:     - Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec. ~~Both group-common signaling and UE-specific signaling should be considered for dynamic adaptation.~~ |
| CEWiT | We are fine with the proposal |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Updated based on comments to Proposal #3-3F. Signals aspects seem to be spec change related. Moderator thinks we can just remove it. |
| ITRI | We are OK with FL’s proposal. |
| APPLE | OK |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
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#### Other Aspects (not part of agreement)

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

##### Technique #B-1: Multi-carrier energy savings enhancements

* + Potential specification impact:
    - Specification impact includes impact on RRM/CSI measurement and how UE can be informed about resource for on-demand or WUS type of uplink triggering signal
    - Clarify QCL source for receiving/transmitting channels especially when QCL source is related to SSB
    - Mechanism to trigger SSB transmission or simplified SSB transmission in the SSB-less Scell (e.g., by using some uplink signal)
    - L1/L2 signalling to indicate primary cell change to a group of UEs
    - Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB at the gNB, might have impact to the UE normal access to the network, such as measurements, RRM and mobility.
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell cannot be performed, there may include mechanism for UE to trigger normal SSB transmission on a SCell, where the on-demand or WUS type of uplink triggering signal can be transmitted at another serving cell.
    - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.
    - The legacy UEs may not operate in the cell with this technique
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Signals/channels for UE request and L1 indication in L1 based SCell activation/deactivation
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Specification impact includes enhancements on SCell activation procedure.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
  + Additional aspects to be considered together with operation of SCells without or with reduced transmission of periodic transmission and reception are:
    - UE specific or UE group-common signaling to (de)activate SCell(s), and/or Pcell change
    - Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP
    - Quick activation and deactivation of CC, for example, based on on-demand RS, aperiodic DL/UL RS, UE request, and L1 response and L1 activation command

##### Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier

* + The reduction of RF BW had shown the reduction in energy consumption in LTE e-MTC. The dynamic adaptation of Tx BW of gNB RF by BWP switching in a cell could achieve network energy saving.Potential specification impact:
    - Signalling details to support UE group-common or cell-specific BWP configuration and/or switching
    - Semi-static configuration of cell specific BWPs
    - L1 signaling in cell specific BWP switching indication
    - Signalling details to support UE group-common or cell-specific configuration and/or switching of BWP for network energy saving state
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The cell-specific BWP switching delay
    - Interaction of cell-specific BWP switching and legacy UE-specific BWP switching.

##### Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs

* + Potential specification impact:
    - Signalling details to support group-common or UE-specific bandwidth adaptation
    - UE’s behavior that is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP
    - Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Introduce some frequency resource scheduling restriction within the active BWP.
    - Clarify that UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.
    - Dynamic indication of an active bandwidth of an active BWP
    - Impacts on preconfigured operations (e.g. CSI-RS,configured grant, etc.) in deactivated portion of the active BWP
    - Signalling mechanism for adaptation of active BWP
    - Signalling of deactivated portion (e.g., in terms of number of RBs and starting RB)
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - No impact to legacy UE is expected, since network implementation can avoid any impact to legacy UE operation.

#### Company Comments on other aspects

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| Company | Comments |
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### == Summary of 4th Round Discussions ==

The proposals are getting more stable. Here are the updates proposals for frequency domain techniques. Moderator suggests agreeing the following proposal.

#### Proposal #3-1H

* Technique #B-1: Multi-carrier energy savings enhancements
  + Background:
    - Intra-band SSB-less Scell operation has already been supported by the current specification
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.
  + Inter-band CA with SSB-less carriers/Scell
    - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission or same cell with simplified signal transmission, also in order for fast activation and deactivation of SCell.
    - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand uplink triggering signal can be received either at inter-band SSB-less cell or another carrier/cell, and supporting RACH transmission opportunity in SSB -less Scell.
  + Dynamic UE-group Pcell switching
    - To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.
  + Potential impact to other WGS
    - RAN2:
      * For inter-band CA with SSB-less Scell:
        + RACH procedures in SSB-less Scell
      * Impact on procedure for dynamic Pcell switching
    - RAN3:
    - RAN4:
      * Feasibility of inter-band SSB-less Scell

#### Proposal #3-2F

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission/SP-CSI reporting on PUSCH without reactivation after the BWP switching.
  + Background:
    - In Rel-17, UE-specific BWP configuration and switching is supported.
    - For SPS PDSCH reception, type-2 CG PUSCH transmission, and SP-CSI reporting on PUSCH, once BWP is switched, they should be reactivated by activation DCI.
  + Potential impact to other WGS
    - RAN2:
      * Impact on BWP switching procedure and configuration for UE group-common or cell-specific BWP.
    - RAN3:
    - RAN4:

#### Proposal #3-3F

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP. Some frequency resources within the active BWP may be deactivated.
  + Background:
    - Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:

## 2.4 Spatial-domain based Energy Saving Techniques

* [2] Huawei/HiSilicon
  + Observation 11: Dynamic antenna adaptation applied to PDSCH has the potential of BS energy savings with room of performance improvement by CSI measurement enhancement, while dynamic antenna adaptation of reference signals has limited potential for energy saving with large specification/performance impact.
  + Proposal 5: Evaluate dynamic antenna port shutdown with one CSI report with multiple CSI results (e.g. 4), corresponding to multiple shutdown pattern(s) prior to or after UE measurement/reports.
  + Observation 12: The spatial domain impact on dynamic TRxP adaptation should be further justified.
  + Observation 13: Considerable power saving gain with small performance loss can be achieved by dynamic PSD back-off using multiple CSIs with different corresponding PSD back-off ratios.
  + Proposal 6: Evaluate dynamic DL transmission power back-off technique assuming one CSI report including multiple CSI results (e.g. 4), in which each corresponds to a power offset between PDSCH and CSI-RS
  + The transmission power of SSB/CSI-RS is assumed to be unchanged.
  + Observation 14: UE assisted power enhancement mechanisms, e.g. OTA DPD and DpoD, cause significant UE hardware impact, and require RAN4 expertise for further study.
* [3] Nokia, NSB
  + Observation-6: At least intuitively, spatial domain techniques such dynamic port adaptation and dynamic TRP adaption are expected to provide important network energy saving gains.
  + Proposal-8: Support considering and evaluating dynamic port adaptation technique in terms of network energy saving gains.
  + Proposal-9: Support considering and evaluating dynamic TRP adaptation technique in terms of network energy saving gains.
  + Observation-7: Dynamic port adaptation would have implications on some CSI-RS configuration parameters. For instance, CBSR (codebook-subset restriction) may be different between the case where a port subset is enabled and the case where this subset is disabled.
  + Proposal-10: For dynamic port adaptation, consider group-common signaling for CSI-RS port disabling/enabling indication.
  + Proposal-11: For enabling dynamic port adaptation, consider low-overhead ways by leveraging existing operations such as ZP-CSI-RS related operation.
  + Proposal-12: Under dynamic port adaptation, consider defining UE behaviour regarding measurements and reporting.
  + Proposal-13: For dynamic port adaptation, consider the impact of the transmission of aperiodic CSI-RS and periodic CSI-RS with different number of ports.
  + Observation-8: For the state-of-art MIMO operation in 5G NR, the adaptation of spatial elements, i.e., adaptation of logical antenna port, is operated at a rather large time scale, due to the hardware limitations with large spatial element activation delays.
  + Proposal-14: Discuss hardware limitations about the time required for gNB to perform spatial elements adaptation.
  + Observation-9: For enabling dynamic TRP muting/unmuting (including for CA cases), similar approaches as for enabling legacy SCell deactivation/activation seem workable, i.e., approaches based on explicit indication and ‘activity-aware’ timer.
  + Proposal-15: For dynamic TRP muting/unmuting, impact on UE measurement and reporting should be considered.
  + Proposal-16: For dynamic TRP muting/unmuting, impact on the Rel-17 per-TRP beam failure and recovery operations should be considered.
  + Proposal-17: For dynamic TRP muting/unmuting, consider how to identify/represent a TRP.
* [4] Spreadtrum Communications
  + Observation 7: The reduction of beams of common signal/channel can provide the energy saving gain, but it needs be realized by other techniques, e.g. dynamic cell on/off and DTX.
  + Observation 8: TRxP(s) on/off adaptation can provide the energy saving gain.
* [5] vivo
  + Observation 5: TRP adaption in Technique #C-2 can be deemed as a set of ports adaptation in Technique #C-1, thus Technique #C-1 and #C-2 can be merged.
  + Proposal 10: Study dynamic adaptation of following types of spatial elements for network energy saving.
    - Type 1: enable/disable all spatial elements associated with a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
    - Type 2: enable/disable part of spatial elements associated with a logical antenna port(s).
    - Type 3: enable/disable all spatial elements associated with a TRP.
  + Observation 6: Dynamic port adaptation (switching between 64 ports and 8 ports) can achieve more power saving gain than semi-static way.
  + Proposal 11 : Study group common signaling to indicate spatial Related information such as the number of ports, the adaptation of CSI-RS configuration, CSI report configuration, TRP adaptation, TCI state updating, etc.
  + Observation 7: Multi-CSI reporting can alleviate the negative impacts of inaccurate CSI tracking.
  + Proposal 12: Study Multi-CSI for network energy saving to facilitate fast port adaptation with good performance.
  + Proposal 13: Support dynamic adaptation of spatial element technique and capture the following in TR:
    - Technique description: Network dynamically adaptat spatial elements for network energy saving and the related changes need to be notified to UEs. The spatial elements can be adapted in the following ways:
    - Type 1: enable/disable all spatial elements associated with a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
    - Type 2: enable/disable part of spatial elements associated with a logical antenna port(s).
    - Type 3: enable/disable all spatial elements associated with a TRP.
    - Performance analysis: This technique can obtain network energy saving gain compared with the baseline which doesn’t have dynamic spatial element adaptation with acceptable UPT loss;
    - Spec impact: The impacts of dynamic adaption in spatial domain include group common signaling to indicate the information about spatial elements adaptation, CSI measurement enhancement and Multi-CSI reporting, etc.
* [6] China Telecom
  + Proposal 6: The CSI reporting should be enhanced for better deciding the TRX switch on-off.
  + Proposal 7: The network can consider self-adapted switch-off the TRX with the reference of PMI.
  + Proposal 8: The CSI-RS should be reconfigured when the TRX switch off is adopted.
* [7] OPPO
  + Proposal 6: Consider the following text proposal for TR 38.864.
    - Support of reducing the number of active transceiver chains or antenna elements is beneficial to achieve energy saving gain and can be considered.
* [8] CATT
  + Proposal 16: Dynamic antenna adaptation at low/middle system load should be considered.
  + Observation 12: Without change of the number/pattern of antenna ports, dynamic reduction of antenna elements has no obvious specification impact.
  + Observation 13: When multiple periodic/SPS CSI associated with different patterns of antenna ports were configured to measure/report by UE, it will require huge UCI overhead/UL resources and additional UE power consumption.
  + Proposal 17: If dynamic antenna ports adaptation was supported, NZP CSI-RS ports adaptation information should be indicated to UE with group/cell common signaling.
  + Proposal 18: If dynamic antenna ports adaptation was supported, enhanced CSI acquisition/reporting to support friendly coexistence with legacy UEs could be further considered.
  + Proposal 19: Aperiodic CSI report mechanism could be used for support of simultaneous multiple CSI reporting associated with different patterns of antenna ports.
  + Proposal 20: If dynamic antenna adaptation was supported, gNB should ensure no performance loss of cell coverage through implementation.
  + Proposal 21: The dynamic antenna adaptation technique to support the coexistence with legacy UE should be further studied.
  + Observation 14: Dynamic antenna adaptation scheme could obtain 6.9% ~ 10.8% network energy saving gain with 1.2%~1.7% UPT loss and 1.7%~ 2.88% latency loss.
  + Observation 15: When the TRP is dynamically turned off, sparse RS could be transmitted to achieve good trade-off between energy saving gain of gNB and CSI measurement performance of UE.
  + Observation 16: If ON/OFF of multi-TRP is dynamically indicated to UE, energy saving gain can be provided for both Network and UE.
  + Proposal 22: Triggering of dynamic ON/OFF of multi-TRP should be considered.
* [9] Fujitsu
  + Observation 2. TxRU(s) reduction can be considered as the most effective technique in spatial domain for network energy saving.
  + Proposal 4. TxRU(s) reduction can be performed for UL or DL transmission, respectively.
  + Proposal 5. To support dynamic TxRU adaptation, the following enhancements of CSI measurement / report can be considered.
    - For type I TxRU adaptation, L1 signaling to update CSI-RS configuration for periodic / semi-persistent CSI reporting is required due to the dynamic change of the number of logical antenna ports.
    - For type II TxRU adaptation, L1 signaling to inform UE to make measurement(s) and generate report(s) based on the CSI-RS transmitted after TxRU adaptation is needed if mapping between logical antenna port to gNB TxRU(s) is updated.
    - Group-common signaling can be considered to avoid obvious increase of signaling overhead.
  + Proposal 6. For TxRU adaptation and power adjustment, RAN1 should focus on the techniques that has no impact on SSB transmission.
  + Proposal 7. Enhancement(s) on RLM and RRM measurement operation is necessary considering the potential transmission power fluctuation of CSI-RS caused by TxRU adaptation and power adjustment.
* [10] Intel
  + Observation 5: Antenna adaptation provides reduction in power consumption from anywhere between 5% to 30% at the expense of cell/user throughput. In the right circumstances, it might be beneficial for the network to be able to choose disablement of sub portions of the antenna to improve power consumption at the expense of some degradation of cell/user throughput.
  + Observation 6: Antenna elements and ports used by PDCCH and PDSCH can be somewhat flexibly controlled by the gNB.
  + Number of ports used by CSI-RS is configured by RRC.
  + UEs do not expect beam pattern used by CSI-RS to dynamically change, and dynamic change of CSI-RS beam pattern may lead to unsuspected results to RLM, RRM measurements (if used by RLM, RRM measurements), and CSI reporting.
  + Proposal 4: Consider support of more efficient signaling methods to update the number of antenna ports (and other related configuration) for CSI-RS.
* [11] Lenovo
  + Proposal 8: Support enhanced beam reporting, which allows a UE to report the best N beams for each TRP/antenna panel independently in one CSI report, for network energy savings.
  + Proposal 9: Include the following texts in TR38.864:
    - Technique #C-2: Dynamic adaptation of TRPs in mTRP
      * gNB can dynamically turn on/off a particular TRP based on enhanced beam reporting.
    - Analysis for technique #C-2:
      * It is desired that enhanced beam reporting maintains same or similar configuration signaling overhead and measurement time compared to Rel-17 group based beam reporting.
    - Spec impact for technique #C-2:
      * Support of UE reporting the best N beams for each TRP independently in one CSI report.
* [12] ZTE, Sanechips
  + When the antenna configuration is reduced from 64TxRUs to 32TxRUs, 17.7%~26.4% energy saving gain can be observed in the case RU=10%~35% with 3.7%~10.9% UPT loss.
  + The spatial domain adaptation with TxRU activation/de-activation should be supported for network energy saving.
  + RRC reconfiguration is needed to update the configuration of reference signals due to the TxRU de-activation, which will increase the signaling overhead and decrease the spectrum efficiency.
  + CSI measurement results may be out-of-state if partial TxRUs are de-activated.
  + The following issues need to be considered for dynamic spatial domain adaptation
    - The mismatch between the reference signal configurations, including CSI-RS, and the number of TxRUs.
    - The measurement/report results, including CSI measurement/report, may be out-of-state even if the reference signal configuration does not need to be updated.
  + Dynamic indication of CSI-RS re-configuration via DCI or MAC CE for spatial domain adaptation should be supported.
  + The enhancement on CSI measurement/report or UE assistance information should be considered for spatial domain adaptation.
  + Capture the following description of dynamic adaptation of spatial elements in TR
    - Adaptation can be further categorized into two types:
      * Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
      * Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s).
    - UE should be informed an information about the adaptation from gNB via DCI or MAC CE, and perform CSI measurements and reporting according to the indication.
      * The indication includes, e.g., CSI-RS/reporting re-configuration information. It can be different for different adaptation types.
      * Specification impact may include enhancing CSI measurement and reporting procedures, e.g., dynamic indication of re-configuration of CSI-RS, CSI feedback update, transmission power of the reference signal or channel update, UE assistance information.
* [13] Xiaomi
  + Proposal 2: The measurement for RLM/ BFD/ beam selection and recovery/CSI /RRM should be enhanced considering dynamic beam on-off.
  + Proposal 3: Reducing unnecessary DL reference signal transmission for dormant cell can be studied for energy saving.
  + Proposal 4: Flexibly adjusting CSI-RS for RLM/BFD can be studied.
* [14] CMCC
  + Proposal 1: Enhancements can be studied to enable UE to jointly measure CSI-RS or PL RS transmitted before and after TxRUs on/off.
  + Proposal 2: Threshold for beam failure recovery or radio link monitoring may be needed to update together with TxRUs on/off.
  + Proposal 3: Enhancements can be studied to enable adaptation of CQI, RI, or PMI calculation with TxRUs on/off.
  + Proposal 4: Dynamic CSI-RS port adaptation can be studied for semi-static and periodic CSI-RS.
  + Proposal 5: UE reports multiple CSIs in one CSI reporting to feedback antenna muting pattern recommendations to gNB.
* [15] NEC
  + Proposal 8: jointly design of spatial domain and frequency domain techniques should be considered to get good balance among energy consumption, coverage and capacity, e.g., joint antenna on/off and BWP switching.
  + Proposal 9: support SSB and CSI-RS updating mechanism due to the dynamic antenna switching on/off, and techniques to reduce the delay of UE beam measurement and TCI state update after SSB updating should be studied.
  + Proposal 10: Consider using an associated TRX pool index to address the spatial domain configuration whenever the network enters into the energy saving mode.
  + Proposal 11: Consider the activation of different network energy saving techniques (e.g., time, frequency, spatial, power) via semi-static network energy saving configuration.
* [16] LGE
  + Proposal #2: It is beneficial to dynamically adjust the number of gNB’s activated antenna elements, in terms of network energy savings.
  + Proposal #3: Study how to efficiently support dynamically muting TRPs for multi-TRP operation or changing the number of gNB’s transmit antenna elements (e.g., by deactivating a NZP CSI-RS with 32 antenna ports while activating another NZP CSI-RS with 16 antenna ports, or turning off 16 antenna ports out of 32 antenna ports configured for the NZP CSI-RS) and how to handle related issues such as indication methods, beam management, and TCI state/configuration control.
  + Proposal #4: Discuss whether any enhancements for UL signal/channel (e.g., SRS) transmission are needed depending on the number of gNB’s receive spatial elements.
* [17] Mediatek
  + Observation 5: For the NW scenario with light load (15% - 30%), reducing #TxRU from 64 to 32 can bring 15.3% and 16.8% NW energy saving gain, respectively, for Cat 1 BS and Cat 2 BS, subject to 4.8% increment in average data packet latency. Further reducing #TxRU to 16 only bring <6% additional energy saving gain while causing >15% data latency increment.
  + Observation 6: For the NW scenario with medium load (30% - 50%), reducing #TxRU from 64 to 32 can bring 25.3% and 26.8% NW energy saving gain, respectively, for Cat 1 BS and Cat 2 BS, subject to 6.8% increment in average data packet latency. Further reducing #TxRU to 16 only bring <10% additional energy saving gain while causing >70% data latency increment.
  + Proposal 7: Reducing #TxRU by a limited factor is recommended for NW energy saving.
  + Proposal 8: Further investigate how to extend BWP framework to accommodate changing #TxRU in a UE-group-specific or cell-specific manner.
    - At least CSI-RS and CSI reporting related settings should be adapted accordingly
  + Proposal 9: Study on dynamic adaptation of TRPs in mTRP is deprioritized for focusing on energy saving for BS with larger power consumption (e.g., FR1 macro gNBs).
* [18] Apple
  + Technique #C-1: Dynamic adaptation of spatial elements
    - gNB may conserve energy by reducing the number of active transceiver chains or antenna elements.
    - CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state
    - Adaptation can be further categorized into two types:
      * Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
      * Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, ~~gains,~~ TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).
    - ~~Both~~ Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS configurations, CSI-RS and PL RS measurements, CSI reporting, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure.
    - CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback.
    - [Comment] It is not clear how CSI reporting is done on muted spatial elements and how this assists gNB.
    - Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
    - The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.
    - [Comment] This description does not seem clear. It seems to be discussing a very specific type of enhancements for CSI-RS configuration/measurement/reporting. If this is to be included, should we also include detailed description of other potential solutions?
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations.
    - Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of antenna ports.
    - UE feeding back antenna muting pattern recommendations to the gNB.
  + Technique #C-2: Dynamic adaptation of TRPs in mTRP
    - Adaptation is categorized as type 3:
      * Type 3: activate/deactivate a set of spatial elements corresponding to a TRP, e.g., ~~TRP on/off,~~ activating N1-port CSI-RS resource (set) corresponding to one TRP and/or deactivating N2-port CSI-RS resource (set) corresponding to another TRP
    - Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - [Comment] It is not clear how dynamic signaling for TRP ID address the issue.
    - ~~Dynamic adaption of non-colocated antenna elements, such as different TRP.~~
    - gNB may conserve energy by reducing the number of active TRPs in the mTRP deployment.
    - This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
* [20] Rakuten
  + Proposal 1: Support UE CSI reports for different CSI configurations.
* [21] Panasonic
  + Proposal 3: As of spatial/antenna domain adaptation for network energy saving, the SSB on/off can be discussed and potentially supported together with time domain adaptation. It may possibly be supported by using BWP framework. For the enhancement to the TCI frameworks and CSI feedback, it needs more investigation on whether additional mechanism is needed, especially considering the ongoing work on Rel.18 MIMO enhancement on unified TCI framework for single/multiple-TRP
* [22] Interdigital
  + Proposal 3: Capture the following in TR38.864 (changes from R1-2208185 indicated in red):

|  |
| --- |
| Spatial Domain Techniques   * Technique #C-1: Dynamic adaptation of spatial elements   + gNB may conserve energy by reducing the number of active transceiver chains or antenna elements.   + CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state   + Adaptation can be further categorized into two types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.     - Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, ~~gains,~~ TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).   + ~~Both~~ Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure.   + CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback.   + Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.   + The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations.   + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of antenna ports.   + UE feeding back antenna muting pattern recommendations to the gNB.   + Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources. * Technique #C-2: Dynamic adaptation of TRPs in mTRP   + Adaptation is categorized as type 3:     - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)   + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).   + Dynamic adaption of non-colocated antenna elements, such as different TRP.   + gNB may conserve energy by reducing the number of active TRPs in the mTRP deployment.   + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.   + Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc |

* [23] Samsung
  + Proposal 17: Consider mechanisms to dynamically mute CSI-RS ports for NW energy savings.
  + Proposal 18: Consider mechanisms of power adaptation on CSI-RS ports for NW energy savings.
  + Proposal 19: Consider mechanisms of beam adaptation on CSI-RS ports for NW energy savings.
  + Proposal 20: Consider CSI feedback reporting enhancement for each codebook (Type-1 (R15), Type-2 (R16), eType-2 (R17 Port-selection)) with dynamic adaptation of spatial elements.
  + Proposal 21: Consider both s-TRP and m-TRP scenarios for adaptation on CSI-Ports for NW triggered and UE autonomous operation.
  + Proposal 22: Consider DCI and/or MAC CE based signalling for fast indication of NW energy saving specific TCI and CSI-RS reconfiguration.
  + Proposal 23: Consider TCI to CSI-RS port mapping for fast re-configuration during NW energy saving operation.
  + Proposal 24: Consider the following changes to the TP for TR
    - Technique #C-1: Dynamic adaptation of spatial elements
      * gNB may conserve energy by reducing the number of spatial elements e.g.: active transceiver chains ~~or~~, subarrays, antenna elements, panels, TRPs).
      * CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state. Support mechanisms to trigger gNB/cell power state and to recover back into normal network power state.
      * Adaptation can be further categorized into two types:
        + Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
        + Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).
        + ~~Type 1 and Type 2~~Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).
      * Type-2 and Type 3 should also consider power adaptation on the spatial elements associated with the antenna ports.
      * Type 1, Type 2 and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, efficient and dynamic reconfiguration (using MAC CE, DCI, etc.), cell (re)selection and handover procedure.
      * CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback.
      * Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
      * The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.
      * Support of light-weight mechanisms such as DCI/MAC-CE-based, group common L1 signaling, etc. that allow fast CSI-RS reconfigurations.
      * Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of antenna ports should be considered.
      * UE feeding back antenna muting pattern recommendations, CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - Technique #C-2: Dynamic adaptation of TRPs in mTRP
      * Adaptation is categorized as type 3:
        + Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)
      * Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
      * Dynamic adaption of non-colocated antenna elements, such as different TRP.
      * gNB may conserve energy by dynamically reducing the number of active TRPs in the mTRP deployment.
      * This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
      * Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
* [24] Ericsson
  + A need for increasing number of transceiver chains is foreseen in gNBs in the future, especially at higher frequencies.
  + For efficient beam management, increased number of transceiver chains results in a higher number of energy consuming components and reference signal transmissions.
  + Higher number of antennas results in a high energy consumption even in low to medium load scenarios.
  + Changes in gNB port to antenna mapping may require reference signal reconfiguration.
  + To avoid recurrent reconfigurations, it is necessary for the gNB to acquire knowledge of what performance the different muting patterns would result in prior to the actual transceiver muting decision.
  + In current specifications, multiple CSI-RS resources need to be configured in the UE so that the gNB can get CSI feedback for different antenna muting layouts, which can increase physical resource usage.
  + Reference signal reconfigurations via RRC is slow and leads to excessive energy consumption.
  + Study methods that allow the UE to provide CSI feedback for different port muting patterns based on one CSI-RS resource configuration.
  + Different port muting patterns can be associated with different subset of ports of a CSI-RS resource set configuration. DCI and/or MAC-Ces can be used to indicate to UE(s) which subset of ports to measure/report and when.
  + Using few antennas for data transmission, while maintaining some reference signals transmission in the background on more antennas still brings major energy savings.
  + Excessive CSI reporting/polling for turning on/off transceiver chains is quite energy consuming both for the UE and for the network.
  + Study and identify techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of CSI-RS ports.
  + Study optimized CSI reporting contents allowing the UE to provide compact CSI feedback for different antenna muting patterns, e.g., relative reports compared to a baseline.
* [25] NTT Docomo
  + Proposal 5: Dynamic adaptation of spatial elements can be categorized into three types. They can be used for both single TRP scenario and multi-TRP scenario
    - Type 1: Enable/Disable one or some of the port(s) of the RS resource
    - Type 2: Enable/Disable the RS resource (s)
    - Type 3: Enable/Disable the CSI report configuration(s)
* [26] Qualcomm
  + Observation 7: Dynamic antenna port adaptation could help gNB dynamically adapt antenna port configurations for reducing network power consumption.
  + Observation 8: Dynamic antenna port adaptation could be implemented by the current NR specifications, but such implementation is not efficient.
  + Observation 9: Some enhancements on physical layer procedures e.g., CSI framework and/or transmit power signaling might be introduced to make dynamic antenna port adaptation more efficient.
  + Proposal 8: Capture in TR the following description for dynamic gNB antenna port adaptation
    - Dynamic gNB antenna port adaptation is a technique that allows the gNB to dynamically turn on/off some chains for transmitting and/or receiving PDSCH and/or PUSCH. The technique is not applicable to broadcast channels/signals (e.g., SSB/SI/paging).
    - Reducing the number of antenna ports can provide the network energy savings at the expense of reduction in UPT and coverage. For example, with Set1 FR1 reference configuration, reducing the number of antenna ports from 64 to 32 provides 22% and 21% average network energy savings in low and light load scenarios, respectively. However, the average UPT is reduced by 31% in low load and 30% in light load. Furthermore, the DL SINR at 5 percentile (i.e., cell edge users) is reduced by 4.5dB in low load and 9dB in light load.
    - Specification impact may include enhancing physical layer procedures (e.g., CSI framework) to efficiently achieve network energy savings gain with minimal impact to user experience.
  + Observation 10: Dynamic TRP dormancy might be implemented by the current NR specifications, but such implementation is not efficient.
  + Observation 11: Some TRP dormancy enhancements e.g., UE group specific TRP dormancy indication to make dynamic TRP dormancy more efficient.
  + Proposal 9: Capture in TR the following description for dynamic TRP adaptation
    - Dynamic TRP adaptation is a technique that allows the gNB to dynamically turn on/off one of TRPs.
    - For Set 1 FR1 reference configuration, reducing multi-TRP to single TRP can provide 40% average network energy savings with 16% average UPT reduction in low load, and 24% average network energy savings with 22% average UPT reduction in light load.
    - Specification impact may include dynamic TRP indication from gNB to one or a group of UEs.
* [27] ITRI
  + Proposal 3: The following aspects for the adaptation of number of spatial elements of the gNB can be considered:
    - Dynamic adaptation of the number of antenna ports according to the energy saving state(s) or sleep mode(s)
    - Dynamic adaptation of the number of antenna elements according to the energy saving state(s) or sleep mode(s)
* [28] CEWiT
  + Proposal 8: gNB dynamically adapting the logical ports for energy saving is supported.
  + Proposal 9: gNB dynamically signaling information about ports adaptation to the UE is supported.
    - UE implicitly updating the CSI-RS resource configuration based on ports adaptation is supported.

### [CLOSED] 1st Round Discussions

Companies should start thinking about what potential techniques to capture and what information would be captured together with the techniques. Moderator suggests refining the technique description further based on what was discussed in RAN1 #110. Discussion should include any suggestions to splitting or merging the techniques listed.

Please comment further on the following proposals, including comments to address notes from the moderator below.

#### Proposal #4-1

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #C-1: Dynamic adaptation of spatial elements
  + reducing the number of active transceiver chains or antenna elements.
  + CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state
  + Adaptation can be further categorized into two types:
    - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
    - Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, ~~gains,~~ TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).(1)
  + ~~Both~~ Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure. (2)
  + CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback. (2)
  + Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc. (2)
  + The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.
  + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations.(3)
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of antenna ports.(4)
  + UE feeding back antenna muting pattern recommendations to the gNB.

Notes from the moderator on above:

* Note (1) Need to Clarify (enough to be able to be evaluated by companies)
  + Refinement may be preferred as they are generally discussing the same issues
* Note (2) Need to Clarify (enough to be able to be evaluated by companies)
  + Refinement may be preferred as they are generally discussing the same issues
* Note (3) Need to Clarify (enough to be able to be evaluated by companies)
  + Does this include similar technique in time domain, e.g. dynamic adaptation of UE specific signals and channels?
* Note (4) Need to Clarify (enough to be able to be evaluated by companies)
  + This does not sound like techniques, rather applicable scenarios/cases that could be captured together with results, as part of performance analysis.

#### Company Comments on Proposal #4-1

|  |  |
| --- | --- |
| Company | Comments |
| Xiaomi | For note (3), our opinion is, if it is just faster CSI-RS reconfiguration, the related solution is better to be categorized to Time domain techniques. But if it is dynamic/semi-persistent ON-OFF of CSI-RS, it should be classified to Spatial domain techniques |
| DOCOMO | The most important issue of spatial-domain discussion is to identify the categories of spatial adaptation. Firstly, Type 3 in Proposal #4-2 (mTRP) is also suitable for Proposal #4-1 (single-TRP). Secondly, for “activate/deactivate a set of spatial elements”, one of the approaches is activating/deactivating of the CSI report configuration which associated with a N-port CSI-RS resource (set). We suggest the following update.   * + Adaptation can be further categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.     - Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, ~~gains,~~ TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).     - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)   + ~~Both~~ Type 1, ~~and~~ Type 2 and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure. |
| CMCC | For note 1 and 2, the enhancements due to dynamic adaptation of spatial elements could be summarized as follows:   * + - Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). ~~This may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).~~~~(1)~~   + ~~Both Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure.~~ ~~(2)~~   + ~~CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback.~~ ~~(2)~~   + Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc. (2) |
| Lenovo | Note (2): The description can be simplified as follows:  Type 1 and Type 2 may require some enhancements to UE operations, e.g. measurements (e.g. CSI, pathloss, RLM, beam failure detection, mobility), CSI reporting, power control, TCI configuration, SRS transmission, and PUSCH/PDSCH repetition. |
| Vivo | We recommend updating technique C-1 to the following revised version in red, with the reasons marked in blue：   * Technique #C-1: Dynamic adaptation of spatial elements   + reducing the number of active transceiver chains or antenna elements.   + ~~CSI-RS/reporting re-configuration~~ The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state~~   [vivo]: The CSI-RS/reporting re-configuration in the original version is not accurate enough to cover spatial domain-related changes, so it is more appropriate to summarize them together as spatial domain-related changes.   * + Adaptation can be further categorized into two types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.     - Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). ~~This may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).~~~~(1)~~   [vivo]: The above part belongs to impact analysis, instead of technique description   * + ~~Both Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include~~ CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancement. (2)   + CSI reporting enhancement about multi-CSI report with different number of ports. ~~On muted spatial elements patterns can be considered for assistance information feedback.~~ ~~(2)~~   [vivo]: In fact, the purpose of reporting CSI for different nrof ports is to ensure accurate CSI tracking rather than as a UAI for better gNB decision.   * + Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc. (2)   + ~~The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.~~   + [vivo]: The above part needs further clarification. And we think this part can be categorized as CSI-RS reporting enhancement.   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow ~~fast CSI-RS reconfigurations.~~~~(3)~~ fast spatial domain related reconfiguration   [vivo]: Since the adaptation of the spatial element affects many configurations, it is not scientific and comprehensive to summarize only the rewiring of CSI-RS   * + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of antenna ports.(4)   + UE feeding back antenna muting pattern recommendations to the gNB.   + UE feeds back indication to trigger spatial element adaptation |
| Nokia/NSB | - As a general comment, as we stated previously, we prefer to focus on Type 1, i.e., dynamic port adaptation or port activation/deactivation. Also, Type 2 seems more implementation specific, although one could always consider some specs impact there.  - The intention of “CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback” compared to the last bullet-point “UE feeding back antenna muting pattern recommendations to the gNB” is not clear. So, either the difference between these two bullet-points is clarified or they should be potentially combined.  - The following two bullet-points could potentially be combined:   * “Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure” * “Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.”   - We suggest the following update:   * “~~Support~~ potentialenhancements to UE behaviors due to dynamic port adaptation ~~of spatial elements~~ may include: measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.”   - The following seems to be already providing design details, which we think is not really needed at this stage. We thus suggest the proponents of this design details to either update the following bullet-point to keep it at a high level or simply remove it:   * “The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.” |
| LG Electronics | Note (3): The following two bullets seem overlapping. If this is the correct understanding, we can remove the second one.   * + CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations.(3)   Note (5): As commented below, we can add one more example for Type 1 as follows.   * + Adaptation can be further categorized into two types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).   In addition, the following bullet can be removed since it includes so many WI-level details and seems to be generally covered by other sub-bullets.   * + ~~The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.~~ |
| ZTE, Sanechips | The first bullet and third bullet as below are duplicated. The first one can be removed.  For the second bullet, it can be different from the third one. To be specific, the third bullet implies that spatial adaptation happens first, and then it affect the measurement. While for the second bullet, UE can perform CSI measurement/report based on one or multiple spatial pattern, and with these information it helps gNB’s decision about antenna muting.   * + ~~Both Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure~~. (2)   + CSI measurement/reporting enhancement on one or multiple ~~muted~~ spatial elements patterns ~~can be considered~~ for assistance information feedback. (2)   + Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc. (2)   For the following bullets, some suggestion are provided to simplify the description.   * + ~~The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off.~~ Spatial adaptation/re-configuration ~~for the network energy saving~~ may ~~then~~ be indicated ~~determined~~ by ~~mapping the selected TRX ports setting to~~ an ~~associated~~ configuration index. The configuration index can ~~also~~ be associated with ~~used to select~~ the best of directional beams, NZP-CSI-RS configuration and measurement reporting ~~in reportConfig~~. ~~Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.~~ |
| Huawei, HiSilicon | For Technique C-1, we think some too general description should be removed, which does not help to understand the technique. Also, some description with detailed normative stage design should be removed, e.g. using configuration index etc. We can focus on the normative work after the study item phase. Also, some re-configuration bullet is moved as later sub-bullet to make the description more readable.   * Technique #C-1: Dynamic adaptation of spatial elements   + reducing the number of active transceiver chains or antenna elements.   + ~~CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state~~   + Adaptation can be further categorized into two types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.     - Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, ~~gains,~~ TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).(1)   + ~~Both~~ Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure. (2)   + CSI reporting enhancement ~~on muted spatial elements patterns~~ can be considered ~~for~~ ~~assistance~~ to provide information feedback to assist with gNB spatial elements adaptation, e.g. reporting multiple CSIs, which correspond to multiple muting spatial elements patterns respectively, in a CSI report. (2)   + CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state   + ~~Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.~~ ~~(2)~~   + ~~The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.~~   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations.(3)   + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of antenna ports.(4)   + UE feeding back antenna muting pattern recommendations to the gNB. |
| Fujitsu | Regarding Note (3), we suggest the following modification to make it clear that light-weight mechanism is to enable fast CSI-RS reconfiguration due to spatial domain adaptation.  Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations due to spatial element adaptation.(3) |
| Samsung | * We suggest that all spatial elements considered during the study phase should be listed in the TP since network antenna implementations can vary widely. * The current summary includes points like “The different set of ports…” which look extremely specific to a particular type of technique. We feel it might be better to outline the specification requirements to support a family of techniques at this stage instead of narrowly specifying a particular technique which could ultimately be an implementation-specific detail. * Adaptation Type 2 should also allow simultaneous enabling and disabling part of spatial elements associated to a logical antenna port. * Note (4): in our view, feedback and UE assistance information will drive techniques to be applied for NW energy saving. So, we prefer to keep this bullet in this section.   We suggest the following update highlight yellow. Proposal #4-1  * Technique #C-1: Dynamic adaptation of spatial elements   + Reducing the number of active transceiver chains or spatial elements.     - This includes panel-level adaptation if the gNB is equipped with multi-panel antennas.   + CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell ~~power~~operation state. Mechanisms to trigger gNB/cell power state and to recover back into normal network power state.     - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.   + Adaptation can be further categorized into two types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, ~~gains,~~ TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).(1)   + Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure. (2)   + CSI reporting enhancement on muted/adapted spatial elements patterns can be considered for assistance information feedback. (2)   + Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc. (2)   + The ~~different~~ set of ports ~~such as 64/32/8/4~~ and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations and group-common L1 signaling.(3)   + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.(4)   + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB. |
| Intel | It is not clear what cell power state mean here “spatial adaptation of gNB/cell power state”. Perhaps it is better to remove this part.   * + CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB~~/cell power state~~   Some more details are needed to understand the intended operation and potential impact to other procedures in the following bullets   * + Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure. (2)   + CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback. (2)   It is unclear how or based on what information UE could suggest the muting pattern in the following bullet   * + UE feeding back antenna muting pattern recommendations to the gNB.   We should also try to clarify some potential specification impact from support of antenna port adaptation. For example, something like below:   * + Potential specification impacts are:     - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication. |
| CEWiT | The signalling for adapting already assigned CSI-RS configuration is missed out. The adaptation of an active CSI-RS configuration will avoid the need for reconfiguration and associated overhead. Thus, we suggest to include a bullet in proposal #4-1 as follows,  “Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow dynamic adaptation of an active CSI-RS configuration at the UE. For e.g., dynamic on-off of CSI-RS resources within an active CSI-RS configuration w.r.t. adapted ports”   * this may include group common signaling for the adaptation” |
| QCOM1 | RAN1 specs do not have terms “active transceiver chains” or “antenna elements”. Furthermore, it is not clear what “antenna elements” include.  Suggest formulating the proposal with RAN1 spec terminologies.  From our perspectives, the proposal should just focus on description and spec impact of dynamic antenna port adaptation. It is not clear to us what else outside of the antenna port adaptation that the proposal tries to cover. |
| Apple | We would like some clarification on the sub-bullet: “CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback.” How is CSI measurement done on muted spatial elements and how this will assist gNB?  We also suggest removing the following sub-bullet as it is providing a very specific solution for the technique:  “The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.” |
| CATT | We are generally OK with the description as the placeholder for further revision when the results are ready except the following bullet.   1. Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations.(3)   Currently, gNB could configure multiple CSI-RS configuration in the same time for UE to report CSI with different antenna port. Dynamic fast reconfiguration by DCI/MAC-CE does not provide the benefit of reliable CSI report since the CSI measurements requires average to remove the effect of fast fading and robust interference. |
| InterDigital | We suggest including the following description under Proposal #4-1 on group common signaling of applicable CSI-RS resources during adaptation of ports:   * Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources. |
| Ericsson1 | Regarding notes (3), the intention is to be able to also quickly change particular parameters within a CSI-RS resource. For example, this includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc. The corresponding text is updated below.  Regarding notes (4), this was explained in our tdoc (x9859). Some updates are suggested below.  Our suggested updates are as follows:   * + reducing the number of active transceiver chains or antenna elements.   + CSI-RS/reporting re-configuration should be indicated to the UEs for spatial adaptation of gNB/cell power state   + Adaptation can be further categorized into two types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.     - Type 2: enable/disable of part of spatial elements associated to a logical antenna port(s). This may result in changes to the antenna pattern, ~~gains,~~ TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).(1)   + ~~Both~~ Type 1 and Type 2 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure. (2)   + CSI reporting enhancement on muted/to-be-muted spatial elements patterns can be considered for assistance information feedback. (2)     - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses   + Support enhancements to UE behaviors due to dynamic adaptation of spatial elements, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc. (2)   + The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast CSI-RS reconfigurations.(3)     - This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc   + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation of antenna ports.(4)     - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.   + UE feeding back antenna muting pattern recommendations to the gNB. |
| Rakuten S. | The following section seems to include very specific design details and it is not very clear. Can we keep it at a high level, e.g., the first sentence.  “The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.” |

#### Proposal #4-2

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #C-2: Dynamic adaptation of TRPs in mTRP
  + Adaptation is categorized as type 3:
    - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)(5)
  + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
  + Dynamic adaption of non-colocated antenna elements, such as different TRP. (6)
  + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
  + Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc

Notes from the moderator on above:

* Note (5) Need to Clarify (enough to be able to be evaluated by companies)
  + need to clarify the difference with Type 1.
* Note (6) Need to Clarify (enough to be able to be evaluated by companies)
  + More clarification may be preferred to understand the relationship with previous bullets and what exactly to be evaluated, compared to C-2 and C-1.

#### Company Comments on Proposal #4-2

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| --- | --- |
| Company | Comments |
| DOCOMO | The spatial domain impact on dynamic TRxP adaptation should be further justified.  In previous meetings, we discussed that adaptation of TRPs is already supported in R16 and R17 MIMO Wis. For example, gNB(s) can decide which TRP(s) will transmit PDSCH, and UE could detect corresponding DCI if the TRP transmits, and UE could not detect corresponding DCI if TRP off. So, from this point, TRP adaptation is already supported in MTRP operation based on R16/R17.  But one of potential enhancement is whether UE need to measure and report the CSI of muted TRP. From power saving point of view, such enhancement reduces the UE power consumption. As PDSCH reception and CSI measurement is performed in UE active state, and the periodicity of CSI measurement is long, how much UE power consumption could be saved with such enhancement should be further evaluated and clarified. |
| Vivo | We think both the techniques #C-1 and #C-2 need to be considered for NW energy saving in spatial domain. In fact, the technique #C-2 can be a sub-set of technique #C-1, where TRP adaption can be deemed as a set of ports adaptation. In this regard, we propose to merge Technique #C-1 and #C-2 for discussion. |
| Nokia/NSB | - The following statement is not fully clear from our perspective: “Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex)”. Specifically, what does “redundant CSI measurement or reporting to a muted TRP” exactly mean? Also, how to identify a TRP (e.g., using CORESETPoolIndex, TRP index, PCI, etc.) can be further discussed, so no need to mention about CORESETPoolIndex or other ways at this stage.  - On “Dynamic adaption of non-collocated antenna elements, such as different TRP”, in our view, this seems redundant with the Type 3 description as we think it covers dynamic TRP adaptation, i.e., dynamic muting/unmuting or turning on/off of a TRP(s). So, this bullet-point could be potentially removed.  - In addition, we suggest the following updates:   * Type 3: ~~activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)~~ Dynamic TRP adaptation consists in dynamically turning on/off a TRP(s). * “~~Support~~ potential enhancements to UE behaviors due to dynamic TRP adaptation ~~of TRPs~~ may include: measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc ”   Dynamic adaption of a TRP may be achieved through DCI or MAC CE signaling. ~~Of non-colocated antenna elements, such as different TRP~~ Also, similar approaches as for enabling legacy SCell deactivation/activation could be considered to enable dynamic TRP adaptation. |
| LG Electronics | Note (5): The following bullet can be removed if the second example (activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)) can be moved to Type-1.   * + ~~Adaptation is categorized as type 3:~~     - ~~Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)~~~~(5)~~   Note (6): Those two bullets seem to be duplicated, so we can remove the second one.   * + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).   + Dynamic adaption of non-colocated antenna elements, such as different TRP. (6) |
| ZTE, Sanechips | The following red part is also applicable to single TRP case, which can be removed from mTRP, and add in #4-1 if needed.   * + - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)(5)   The following red part is duplicated with the last bullet, which can be removed.   * + ~~Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so~~ enhancement may include dynamic signaling for TRP ID (CORESETPollIndex). |
| Fujitsu | We share the same view as vivo that Technique #C-2 can be merged with Technique #C-1. |
| Samsung | * Some of the points in technique #C-2 look repeated (like “Dynamic adaption of…” and “gNB may conserve…”). We suggest that they be included as part of others points in #C-2.   We suggest the following update highlight yellow.   * + Adaptation is categorized as type 3:     - Type 3: activate and/or deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set) across TRPs.(5)   + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).   + Dynamic adaptation of non-colocated antenna elements, such as different TRP. (6)   + ~~gNB may conserve energy by reducing the number of active TRPs in the mTRP deployment.~~   + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.   Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, s-DCI, m-DCI, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc. |
| Apple | It is not clear to us what kind of dynamic signaling is envisioned for “dynamic signaling for TRP ID (CORESETPollIndex)” and how this helps unnecessary redundant meansurement/reporting. Does it simply mean that the gNB tells the UE which TRP ID is muted? |
| CATT | We are OK with the description as the placeholder for further revision when evaluation results are available. |

### Summary of 1st Round Discussions

Based on feedback received moderator has updated the proposals as follows. Moderator suggest using the updated proposal for further discussions.

Notation of change marks above:

* Red Underline or ~~Stikethrough~~ Text: Updated text based on comments.
* Blue Underline Text: Updated text based on comments. However, moderator thinks further clarification is needed
* Green Text: Unchanged text. However, based on comments, moderator thinks further clarification is needed.

Proposal #4-1A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #C-1: Dynamic adaptation of spatial elements
  + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.
  + ~~CSI-RS/reporting re-configuration~~ The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
  + Adaptation can be further categorized into ~~two~~ following types:
    - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).
    - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s). ~~This may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).~~
    - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)
  + ~~CSI reporting enhancement on muted spatial elements patterns can be considered for assistance information feedback.~~
  + ~~Support~~ Potential enhancements to UE behaviors due to dynamic port adaptation ~~of spatial elements~~, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
  + ~~The different set of ports such as 64/32/8/4 and their associated CSI-RS configurations may be determined from the hypothesis of TRX On/Off. Spatial configuration for the network energy saving may then be determined by mapping the selected TRX ports setting to an associated configuration index. The configuration index can also be used to select the best of directional beams, NZP-CSI-RS configuration and measurement reporting in reportConfig. Over a certain coherent period, whenever the network enters the energy saving mode, the corresponding spatial domain configuration can then be determined from the configuration index.~~
  + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation. ~~Fast CSI-RS reconfigurations~~ such as dynamic/semi-persistent ON-OFF of CSI-RS.
    - Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.
    - This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.
    - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.
  + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses
  + UE feeds back indication to trigger spatial element adaptation
  + Potential specification impact:
    - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhnacements.
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
  + Additional considerations:
    - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).

Proposal #4-2A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #C-2: Dynamic adaptation of TRPs in mTRP
  + Adaptation is categorized as type 3:
    - Type 3: activate and/or deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set) across TRPs
  + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
  + Dynamic adaptation of non-colocated antenna elements, such as different TRP.
  + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
  + Potential specification impact:
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, s-DCI, m-DCI, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc

#### Proposal #4-1A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #C-1: Dynamic adaptation of spatial elements
  + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.
  + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
  + Adaptation can be further categorized into ~~two~~ following types:
    - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).
    - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).
    - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)
  + Potential enhancements to UE behaviors due to dynamic port adaptation, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
  + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.
    - Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.
    - This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.
    - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.
  + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses
  + UE feeds back indication to trigger spatial element adaptation
  + Potential specification impact:
    - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
  + Additional considerations:
    - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).

#### Proposal #4-2A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #C-2: Dynamic adaptation of TRPs in mTRP
  + Adaptation is categorized as type 3:
    - Type 3: activate and/or deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set) across TRPs
  + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
  + Dynamic adaptation of non-colocated antenna elements, such as different TRP.
  + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
  + Potential specification impact:
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, s-DCI, m-DCI, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc

### [CLOSED] 2nd Round Discussions

Based on discussion from GTW, we should split the discussion into two components. First aspect is regarding high level descriptions of the potential techniques, their potential specification impact, any impact to legacy UEs. The second aspect is providing even further details targeting providing information for evaluations.

#### Proposal #4-1B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #C-1: Dynamic adaptation of spatial elements
  + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.
  + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
  + Adaptation can be further categorized into ~~two~~ following types:
    - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).
    - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).
    - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)
  + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.
    - Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.
    - This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc
  + Background:
    - [To be filled]
  + Potential specification impact:
    - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #C-1: Dynamic adaptation of spatial elements
  + Potential enhancements to UE behaviors due to dynamic port adaptation, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.
    - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.
  + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses
  + UE feeds back indication to trigger spatial element adaptation

#### Company Comments on Proposal #4-1B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | This proposal can be further simplified by removing detailed suggestion and type 3 (which is overlapped with Tech #C-2), as follows.   * Technique #C-1: Dynamic adaptation of spatial elements   + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.   + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~   + Adaptation can be further categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).   + Potential specification impact:     - Dynamic adaptation of spatial elements may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.     - Signaling details to indicate changes of the number of active transceiver chains or spatial elements |
| vivo | Thanks for FL’s great effort.  It seems there is still too many details in the technique description, and some of them may belong to potential specification impact such as how to indicate spatial element adaptation. How about we first try to agree on the first three bullets as high-level description, and leave the details in the sub-bullets to be decided in the next meeting when there are more evaluation results available?     * Technique #C-1: Dynamic adaptation of spatial elements   + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.   + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state can ~~should~~ be supported.     - ~~This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.~~   + Adaptation can be further categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).     - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)   + ~~Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.~~     - ~~Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.~~     - ~~This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc~~   + Background:     - [To be filled]   + Potential specification impact:     - ~~Type 1 and Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.~~     - ~~Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.~~   + ~~Additional considerations/aspects (including any impact to legacy UEs, if any):~~     - ~~Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).~~ |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We support FL’s original proposal. |
| QCOM2 | We’ve provided our suggested update in green and red. Some comments for the update are provide in comment panel.   * Technique #C-1: Dynamic adaptation of spatial elements   + The technique aims to dynamically adapt spatial elements such as ~~Reducing~~ the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving UE-specific channels. ~~Antenna spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.~~   + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation ~~of~~ at gNB~~/cell power state~~. ~~Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.~~ [Qualcomm commented: This is already included in “adaptation”. Furthermore, we don’t have definition of “normal network power state”.]     - ~~This may include enhancements CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.~~ [Qualcomm commented: This can be moved to the spec impact]   + Adaptation can be ~~further~~ categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).     - ~~Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)~~ [Qualcomm commented: We can move this to the next proposal.]   + ~~Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.~~ [Qualcomm commented: This belongs to the spec impact]     - ~~Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.~~     - ~~This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc~~   + Background:     - [To be filled]   + Potential specification impact:     - Enhancements to CSI measurement and feedback, BRF, RLM, and RRM.     - Support L1/L2 signalling to inform UE on parameter configurations (e.g., downlink power allocation, TCI state, RS for path loss measurement etc.) to be used with respect to the spatial parameter change.     - ~~Type 1 and Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.~~     - ~~Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.~~   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - ~~Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).~~     - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals. |
| Ericsson2 | We prefer to keep the below highlighted main paragraph text in C-1. We are OK to move the subbullets under it(with an update in red) to “additional description” text outside of C-1.   * + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.     - Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-specific/UE-group common signaling including the group identity of applicable CSI-RS resources.     - This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc   For the following sentence, some rewording is suggested for better alignment with the intention of the paragraph.   * + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell ~~power state and to recover back into normal network power state~~ to switch between different spatial domain configurations can be considered ~~should be supported~~.   For the following sentence in Potential specification impact, suggest below update.   * + - Introduction of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication. |
| DOCOMO | Although some companies suggest removing Type 3 as it is covered in Proposal #4-2B, we still prefer to keep it in Proposal #4-1B as Type 3 could also be used for single TRP adaptation.  Furthermore, how the spatial element mapping to RS ports is per gNB implementation. We should focus on how to indicate the spatial adaptation to UE. From our understanding, Type 1-3 here interprets the categories of spatial adaptation indication from UE perspective. That is UE can be indicated that part of antennas of a RS port (Type 2)/all of the antennas of a RS port (Type1)/all of the antennas of a RS configuration (Type 3) is enabled/disabled.  We suggest the following slight update on categories. Some details could be removed at this stage.   * + Adaptation can be ~~further~~ categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, ~~activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).~~     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).   Type 3: activate/deactivate ~~a set of~~ all spatial elements of a RS configuration, ~~e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)~~ |
| Intel | We think the following is sufficient as high level description   * + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.   + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.     - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.   For impact to other WGs, the following should be added   * RAN4 input on impact to RLM or RRM measurement from adaptation changes to antenna ports configuration might be needed. |
| Apple | Type 3 is included in #4-2B, so it can be removed here.  On DOCOMO’s new proposal for Type 3, it is not so clear to us the benefit of activating/deactivating a RS configuration. As a RS configuration includes multiple ports, does it mean all the ports associated with the RS configuration are deactivated? If so, this can be done via Type 2 already just by activating/deactivating multiple ports. |
| Samsung | * We are in general fine with the proposal as a whole. * Some minor comments on NES state to stay consistent. * Configuring group based CSI-RS will have non-trivial impact on specs and it is little early to get into those details at this stage.   Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #C-1: Dynamic adaptation of spatial elements   + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.   + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell ~~power~~ NES state and to recover back into normal network ~~power~~ operation state should be supported.   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.     - Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs ~~by configuring for each UE a group identity to each CSI-RS resource~~ and indicating change by UE-group common signaling ~~including the group identity of applicable CSI-RS resources.~~   + Potential specification impact:     - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.     - ~~Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.~~ |
| CMCC | The technique description may be further simplified, and some description may be moved to spec impact.   * + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.     - ~~This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.~~   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.     - ~~Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.~~     - ~~This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc~~   We also suggest to move Type-3 to Proposal #4-2B.  Besides, potential enhancements to UE behaviors should be captured in TR, which will solve the problem due to dynamic port adaptation. UE feeding back antenna muting pattern recommendations also need to be captured in TR, which is a type of assistance information for gNB. Hence, the following two bullet should be included in the main proposal description.   * + Potential enhancements to UE behaviors due to dynamic port adaptation, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.   + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.   We also suggest to add following text in potential specification impact   * + - CSI-RS/reporting reconfiguration to UEs for dynamic adaptation of spatial elements.     - Optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses. |
| CEWiT | We suggest to update the potential impact as follows: Proposal #4-1B Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #C-1: Dynamic adaptation of spatial elements   + Reducing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.   + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.     - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.   + Adaptation can be further categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).     - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)   + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS within an active configuration.     - Adaptation of ~~subset~~/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.     - This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc   + Background:     - [To be filled]   + Potential specification impact:     - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.     - Introduction of group-based ~~reconfiguration~~ adaptation of various reference signal resources, measurement, reporting, be RRC-based or MAC-CE based or by other physical layer indication.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).   + Potential impact to other WGS     - [To be filled] |
| Huawei, HiSilicon | Based on the Chairman’s guideline, we have some comments on proposal #4-1B. Proposal #4-1B Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #C-1: Dynamic adaptation of spatial elements   + Dynamic ~~R~~reducing/increasing the number of active transceiver chains or ~~antenna~~ spatial elements, including panel-level adaptation if the gNB is equipped with multi-panel antennas.   + [Huawei commented on the following removed bullets: Obviously, it is not the high-level description of the technique. We move it to potential specification impact.]   + ~~The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB/cell power state. Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.~~      - ~~This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.~~   + Adaptation can be further categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).     - Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)   + [Huawei commented on the following removed bullets: Comments: Obviously, it is the potential specification impact. So, we put this bullet to potential specification impact.]   + ~~Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.~~     - ~~Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.~~     - ~~This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc~~   + Background:     - [To be filled] Dynamic adaptation of spatial elements is a technique that allows the gNB to dynamically turn on/off some active transceiver chains or spatial elements. The technique should be applicable to PDSCH/PUSCH. Besides, The technique may be applicable to reference signals (e.g. CSI-RS) and/or broadcast channels/signals (e.g., SSB/SI/paging)   + Potential specification impact:     - The related changes in spatial domain caused by spatial element adaptation should be indicated/configured to the UEs for the spatial adaptation of gNB/cell power state. Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.     - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.     - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation (if dynamic spatial elements adaptation will impact CSI-RS, SSB ...), so the potential enhancement may include     - CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements, e.g. UE behavior enhancement.     - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.     - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.     - [Huawei commented on the following removed bullets: This should be WI phase work]     - ~~Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources.~~     - ~~This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc~~     - Need of UE assistant information, e.g.     - Enhanced CSI report, e.g. reporting multiple CSIs, which correspond to multiple muting spatial elements patterns respectively, in a CSI report, and corresponding CSI-RS/CSI reporting configuration enhancement     - antenna muting pattern recommendations     - indication to trigger spatial element adaptation |
| Fujitsu | We are generally fine with the QC’s updated version. Regarding additional consideration / aspects, the reduction in transmission power due to spatial element reduction can be compensated by some approaches, transmission power boosting for example. Therefore, we suggest the following update in purple on top of QC’s version:   * + Additional considerations/aspects (including any impact to legacy UEs, if any):     - ~~Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s).~~     - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, if the technique is ~~not applicable~~ applied to the broadcast channels and signals, approaches such as power boosting should be considered to guarantee cell coverage. |
| ZTE, Sanechips | We can start with a short and brief technique description.   * Technique #C-1: Dynamic adaptation of spatial elements   + Adaptation of ~~Reducing~~ the number of active transceiver chains or ~~antenna~~ spatial elements~~, including panel-level adaptation if the gNB is equipped with multi-panel antennas.~~   + The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB~~/cell power state.~~ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.   [comments]The following bullet is spec impact.   * + - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell ~~operation states~~ configurations and dynamic triggering of one of such configurations.   + Adaptation can be further categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set).     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).     - ~~Type 3: activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set), activating/deactivating CSI report(s) which associated with CSI-RS resource (set)~~   [comments]The following bullet is spec impact.   * + Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.     - Indication of adaptation of subset/number of ports for CSI-RS resources ~~can be efficiently indicated to group of UEs by configuring for each UE a group identity to each CSI-RS resource and indicating change~~ by UE-group common signaling ~~including the group identity of applicable CSI-RS resources~~.     - This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc   The spec impact also includes the following,   * + Potential specification impact:     - Enhanced CSI measurement/reporting to support multiple CSI-RS resource measurement/reporting |
| InterDigital | We agree with the description under Proposal #4-1B, as it provides relevant and good clarification of Technique #C-1. We do not think simplification suggested by LGE are necessary. |
| Nokia/NSB | We really wonder why Type 3 has been added here, while it includes dynamic TRP muting/unmuting which is covered under Technique C#2. In our view, Type 3 should be removed.  As we stated previously, we prefer to focus on Type 1, i.e., dynamic port adaptation or port activation/deactivation. Type 2 seems more implementation specific, although one could always consider some specs impact there.  - The following point should be further clarified or otherwise be removed. E.g., what is exactly meant by gNB power state? And why “should be supported” is used?   * “ Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported. “   - Is the following already discussing some solution detail? If so, then this would need to be removed.   * “… by configuring for each UE a group identity to each CSI-RS resource and indicating change by UE-group common signaling including the group identity of applicable CSI-RS resources”   Regarding background, we have the following proposal:   * Background:   [To be filled] Section 5.2.1.4 in 38.214 addresses the CSI-RS Resource configuration.  Each CSI Resource Setting is located in the DL BWP (parameter *BWP-id*)  Each CSI Resource Setting *CSI-ResourceConfig* contains a configuration of a list of S≥1 CSI Resource Sets (*csi-RS-ResourceSetList*). The *resourceType* and can be set to aperiodic, periodic, or semi-persistent.  For periodic and semi-persistent CSI Resource Settings, when the UE is configured with g*roupBasedBeamReporting-r17*, the number of CSI Resource Sets configured is S=2, otherwise the number of CSI-RS Resource Sets configured is limited to S=1.  The list is comprised of references to either or both of NZP CSIRS resource set(s) and SS/PBCH block set(s) or the list is comprised of references to CSI-IM resource set(s).  *UE* can beconfigured with multiple *CSI-ResourceConfigs* |
|  |  |

#### Proposal #4-2B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #C-2: Dynamic adaptation of TRPs in mTRP
  + Adaptation is categorized as type 3:
    - Type 3: activate and/or deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set) across TRPs
  + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
  + Dynamic adaptation of non-colocated antenna elements, such as different TRP.
  + Background:
    - [To be filled]
  + Potential specification impact:
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, s-DCI, m-DCI, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #C-2: Dynamic adaptation of TRPs in mTRP
  + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.

#### Company Comments on Proposal #4-2B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | Tech #C-2 description can simplified as follows.   * Technique #C-2: Dynamic TRP muting in multi-TRP operartion   + For a UE configured with multiple TRPs, TRP on/off can be dynamically informed to the UE.   + Potential specification impact:     - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, single-DCI based scheduling, multi-DCI based scheduling, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc     - Signaling details to indicate muted TRP, e.g., based on TRP index or CORESET pool index |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | We support FL’s original proposal. |
| QCOM2 | Here is our suggested text for this proposal:   * The technique aims to dynamically adapt the number of active TRPs in transmitting and/or receiving UE-specific channels. It may include the adaptation of the spatial elements across active TRPs. * Potential specification impact:   + Enhancements to CSI measurement and feedback,   + L1/L2 signalling to inform UE on update for TRP-related parameters due to dynamic TRP on/off. * Additional considerations/aspects (including any impact to legacy UEs, if any):   + The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals especially when the adaptation of the spatial elements is applied across active TRPs. [Qualcomm commented on the last text starting from “when” : This is different from the similar comment made in the previous proposal.] |
| Lenovo | We suggest the following updates in blue:   * + Background:     - In Rel-17 NR, when two CSI resource sets are configured in a CSI report setting for Rel-17 group based beam reporting, UE cannot report the best N beams for each TRP/antenna panel independently.   + Potential specification impact:     - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, s-DCI, m-DCI, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - It is desired that enhanced beam reporting maintains same or similar configuration signaling overhead and measurement time compared to Rel-17 group based beam reporting. |
| Samsung | - We are in general fine with the proposal except below deletion, which appears redundant to us.  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #C-2: Dynamic adaptation of TRPs in mTRP   + Adaptation is categorized as type 3:     - Type 3: activate and/or deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set) across TRPs   + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).   + ~~Dynamic adaptation of non-colocated antenna elements, such as different TRP.~~ |
| Huawei, HiSilicon | It seems type 3 adaptation has been merged into Technique C-1. Do we need to repeat here again on the definition of Type3? |
| Fujitsu | We are fine with FL’s proposal. |
| ZTE, Sanechips | The following part should be spec impact.   * + Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).   + Dynamic adaptation of non-colocated antenna elements, such as different TRP. |
| Nokia/NSB | - As we previously mentioned, the following statement is not fully clear from our perspective: “Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex)”. Specifically, what does “redundant CSI measurement or reporting to a muted TRP” exactly mean? Also, how to identify a TRP (e.g., using CORESETPoolIndex, TRP index, PCI, etc.) can be further discussed, so no need to mention about CORESETPoolIndex or other ways at this stage.  - In addition, we suggest the following updates:   * Type 3: ~~activate/deactivate a set of spatial elements, e.g., TRP on/off, activating N1-port CSI-RS resource (set) and deactivating N2-port CSI-RS resource (set)~~ Dynamic TRP adaptation consists in dynamically turning on/off a TRP(s). * ~~Support~~ potential enhancements to UE behaviors due to dynamic TRP adaptation ~~of TRPs, e.g.,~~ could include: measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, s-DCI, m-DCI, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc   - We still don’t really understand the need for the following bullet-point, as Technique C#2 is exactly about TRP adaptation. We thus suggest removing it.   * “~~Dynamic adaptation of non-colocated antenna elements, such as different TRP.~~” |

### Summary of 2nd Round Discussions

There is depute among companies on whether to include Type 3 (all TRP level) antenna adaptation to Proposal #4-1C. It would be good get a common understanding among companies.

#### Proposal #4-1C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #C-1: Dynamic adaptation of spatial elements
  + Description alternative 1)
    - The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving UE-specific channels.
    - The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB/NES state. Mechanisms to trigger gNB/cell to switch between different spatial domain configurations can be considered.~~/~~
    - Adaptation can be further categorized into ~~two~~ following types:
      * Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
      * Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).
      * Type 3: activate/deactivate all spatial elements of a RS configuration
  + Description Alternative 2)
    - Adaptation of the number of active transceiver chains or antenna spatial elements.
    - The related changes in spatial domain caused by spatial element adaptation should be indicated to the UEs for the spatial adaptation of gNB. Mechanisms to trigger gNB should be supported.
  + Background:
    - Dynamic adaptation of spatial elements is a technique that allows the gNB to dynamically turn on/off some active transceiver chains or spatial elements. The technique should be applicable to PDSCH/PUSCH. Besides, The technique may be applicable to reference signals (e.g. CSI-RS) and/or broadcast channels/signals (e.g., SSB/SI/paging)Section 5.2.1.4 in 38.214 addresses the CSI-RS Resource configuration.
      * Each CSI Resource Setting is located in the DL BWP (parameter BWP-id)
      * Each CSI Resource Setting CSI-ResourceConfig contains a configuration of a list of S≥1 CSI Resource Sets (csi-RS-ResourceSetList). The resourceType and can be set to aperiodic, periodic, or semi-persistent.
      * For periodic and semi-persistent CSI Resource Settings, when the UE is configured with groupBasedBeamReporting-r17, the number of CSI Resource Sets configured is S=2, otherwise the number of CSI-RS Resource Sets configured is limited to S=1.
      * The list is comprised of references to either or both of NZP CSIRS resource set(s) and SS/PBCH block set(s) or the list is comprised of references to CSI-IM resource set(s).
      * UE can be configured with multiple CSI-ResourceConfigs
  + Potential specification impact:
    - The related changes in spatial domain caused by spatial element adaptation should be indicated/configured to the UEs for the spatial adaptation of gNB/cell power state. Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Type 1 and Type 2, and Type 3 may have impact on measurement operation (if dynamic spatial elements adaptation will impact CSI-RS, SSB ...), so the potential enhancement may include
    - CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements, e.g. UE behavior enhancement.
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Enhanced CSI measurement/reporting to support multiple CSI-RS resource measurement/reporting
  + Additional consideration/aspects (including any impact to legacy UEs, if any)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, if the technique is applied to the broadcast channels and signals, approaches such as power boosting should be considered to guarantee cell coverage.
  + Potential impact to other WGS
    - RAN4 input on impact to RLM or RRM measurement from adaptation changes to antenna ports configuration might be needed.

Additional description intended to aid evaluations (not part of agreement)

* Technique #C-1: Dynamic adaptation of spatial elements
  + Potential enhancements to UE behaviors due to dynamic port adaptation, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.
    - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.
  + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses
  + UE feeds back indication to trigger spatial element adaptation
  + Potential specification impact:
    - Dynamic adaptation of spatial elements may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Signaling details to indicate changes of the number of active transceiver chains or spatial elements
    - Enhancements to CSI measurement and feedback, BRF, RLM, and RRM.
    - Support L1/L2 signalling to inform UE on parameter configurations (e.g., downlink power allocation, TCI state, RS for path loss measurement etc.) to be used with respect to the spatial parameter change.
    - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Introduction of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - CSI-RS/reporting reconfiguration to UEs for dynamic adaptation of spatial elements.
    - Optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS within an active configuration.
      * Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs and indicating change by UE-specific/UE-group common signaling.
      * This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc
    - UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.

#### Proposal #4-2C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #C-2: TRP muting in multi-TRP operation
  + For a UE configured with multiple TRPs, TRP on/off can be informed to the UE.
  + The technique aims to dynamically adapt the number of active TRPs in transmitting and/or receiving UE-specific channels. It may include the adaptation of the spatial elements across active TRPs.
  + Technique may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
  + Background:
    - In Rel-17 NR, when two CSI resource sets are configured in a CSI report setting for Rel-17 group based beam reporting, UE cannot report the best N beams for each TRP/antenna panel independently.
  + Potential specification impact:
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, single-DCI based scheduling, multi-DCI based scheduling, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc
    - Signaling details to indicate muted TRP, e.g., based on TRP index or CORESET pool index
    - Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - Enhancements to CSI measurement and feedback,
    - L1/L2 signalling to inform UE on update for TRP-related parameters due to dynamic TRP on/off.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals especially when the adaptation of the spatial elements is applied across active TRPs.
    - It is desired that enhanced beam reporting maintains same or similar configuration signaling overhead and measurement time compared to Rel-17 group based beam reporting.
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #C-2: Dynamic adaptation of TRPs in mTRP
  + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.

### [CLOSED] 3rd Round Discussions

Moderator suggests moving all “potential specification impact” and “Additional considerations/aspects (including any impact to legacy UEs, if any)” out of the initial agreement and to the additional information for now. The potential specification impact likely requires further edits and compressing duplicate information.

For the description to be agreed, moderator suggest focusing on the actual technique general description + background + potential impact to other WG

#### Proposal #4-1D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #C-1: Dynamic adaptation of spatial elements
  + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving UE-specific channels.
  + Potential enhancements related to spatial element adaptation may be indicated to the UEs and mechanisms to trigger gNB to switch between different spatial domain configurations may be considered.
  + Adaptation can be further categorized into ~~two~~ following types:
    - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.
    - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).
    - Type 3: activate/deactivate all spatial elements of a RS configuration
  + Background:
    - Dynamic adaptation of spatial elements is a technique that allows the gNB to dynamically turn on/off some active transceiver chains or spatial elements. The technique should be applicable to PDSCH/PUSCH. Besides, The technique may be applicable to reference signals (e.g. CSI-RS) and/or broadcast channels/signals (e.g., SSB/SI/paging)Section 5.2.1.4 in 38.214 addresses the CSI-RS Resource configuration.
      * Each CSI Resource Setting is located in the DL BWP (parameter BWP-id)
      * Each CSI Resource Setting CSI-ResourceConfig contains a configuration of a list of S≥1 CSI Resource Sets (csi-RS-ResourceSetList). The resourceType and can be set to aperiodic, periodic, or semi-persistent.
      * For periodic and semi-persistent CSI Resource Settings, when the UE is configured with groupBasedBeamReporting-r17, the number of CSI Resource Sets configured is S=2, otherwise the number of CSI-RS Resource Sets configured is limited to S=1.
      * The list is comprised of references to either or both of NZP CSIRS resource set(s) and SS/PBCH block set(s) or the list is comprised of references to CSI-IM resource set(s).
      * UE can be configured with multiple CSI-ResourceConfigs.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * RLM or RRM measurement from adaptation changes to antenna ports configuration.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #C-1: Dynamic adaptation of spatial elements
  + Potential enhancements to UE behaviors due to dynamic port adaptation, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.
    - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.
  + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses
  + UE feeds back indication to trigger spatial element adaptation
  + Potential specification impact:
    - The related changes in spatial domain caused by spatial element adaptation should be indicated/configured to the UEs for the spatial adaptation of gNB/cell power state. Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Type 1 and Type 2, and Type 3 may have impact on measurement operation (if dynamic spatial elements adaptation will impact CSI-RS, SSB ...), so the potential enhancement may include
    - CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements, e.g. UE behavior enhancement.
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Enhanced CSI measurement/reporting to support multiple CSI-RS resource measurement/reporting
    - Dynamic adaptation of spatial elements may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Signaling details to indicate changes of the number of active transceiver chains or spatial elements
    - Enhancements to CSI measurement and feedback, BRF, RLM, and RRM.
    - Support L1/L2 signalling to inform UE on parameter configurations (e.g., downlink power allocation, TCI state, RS for path loss measurement etc.) to be used with respect to the spatial parameter change.
    - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Introduction of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - CSI-RS/reporting reconfiguration to UEs for dynamic adaptation of spatial elements.
    - Optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS within an active configuration.
      * Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs and indicating change by UE-specific/UE-group common signaling.
      * This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc
    - UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB
  + Additional consideration/aspects (including any impact to legacy UEs, if any)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, if the technique is applied to the broadcast channels and signals, approaches such as power boosting should be considered to guarantee cell coverage.
    - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.

#### Company Comments on Proposal #4-1D

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | Adaptation of spatial element may also have impact on RSs and cell-specific signals, a general description is better at this early time.   * Technique #C-1: Dynamic adaptation of spatial elements   + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving ~~UE-specific~~ channels and signals.   + Background:     - Dynamic adaptation of spatial elements is a technique that allows the gNB to dynamically turn on/off some active transceiver chains or spatial elements. The technique ~~should~~ may be applicable to PDSCH/PUSCH,~~. Besides, The technique may be applicable to~~ reference signals (e.g. CSI-RS) and/or broadcast channels/signals (e.g., SSB/SI/paging).   Potential RAN2 impact may be:  RAN2 impact: signaling to trigger the change of spatial element configuration to UEs. Impact on mobility due to dynamic adaptation of spatial elements on CSI-RS/SSB. |
| CEWiT | The main description should be general enough to include all possibilities as given in potential specification impacts and additional aspects. The background doestn’t talk about the adaptation of already configured CSI-RS. Therefore we suggest to update the background as follows:   * + Background:     - Dynamic adaptation of spatial elements is a technique that allows the gNB to dynamically turn on/off some active transceiver chains or spatial elements. The technique should be applicable to PDSCH/PUSCH. Besides, The technique may be applicable to reference signals (e.g. CSI-RS) and/or broadcast channels/signals (e.g., SSB/SI/paging)     - Section 5.2.1.4 in 38.214 addresses the CSI-RS Resource configuration.       * Each CSI Resource Setting is located in the DL BWP (parameter BWP-id)       * Each CSI Resource Setting CSI-ResourceConfig contains a configuration of a list of S≥1 CSI Resource Sets (csi-RS-ResourceSetList). The resourceType and can be set to aperiodic, periodic, or semi-persistent.       * For periodic and semi-persistent CSI Resource Settings, when the UE is configured with groupBasedBeamReporting-r17, the number of CSI Resource Sets configured is S=2, otherwise the number of CSI-RS Resource Sets configured is limited to S=1.       * The list is comprised of references to either or both of NZP CSIRS resource set(s) and SS/PBCH block set(s) or the list is comprised of references to CSI-IM resource set(s).       * UE can be configured with multiple CSI-ResourceConfigs.     - Indication for potential enhancements related to spatial element adaptation will help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports. |
| CATT | We are OK with moderator’s proposal without further suggested modification. |
| Nokia/NSB | - We wonder, is there a need/reason to be limiting the description at this stage with the use of “UE-specific channels”? Maybe we could keep it a bit more general by using “… ~~UE-specific~~ signals and/or channels”.  - We are not sure why and additional Type has been added, so we suggest removing the following newly added Type.   * “~~Type 3: activate/deactivate all spatial elements of a RS configuration~~”.   Also, as we mentioned several times, we prefer to only focus on the dynamic port adaptation approach, but we would be fine with keeping Type 1 and Type 2 if preferred by the majority.  - We could be fine with keeping the Background bullet-point on a high level, as suggested by other companies, or even to remove it if not essential. Specifically, we are fine if at least the following is removed:  “Section 5.2.1.4 in 38.214 addresses the CSI-RS Resource configuration.   * Each CSI Resource Setting is located in the DL BWP (parameter BWP-id) * Each CSI Resource Setting CSI-ResourceConfig contains a configuration of a list of S≥1 CSI Resource Sets (csi-RS-ResourceSetList). The resourceType and can be set to aperiodic, periodic, or semi-persistent. * For periodic and semi-persistent CSI Resource Settings, when the UE is configured with groupBasedBeamReporting-r17, the number of CSI Resource Sets configured is S=2, otherwise the number of CSI-RS Resource Sets configured is limited to S=1. * The list is comprised of references to either or both of NZP CSIRS resource set(s) and SS/PBCH block set(s) or the list is comprised of references to CSI-IM resource set(s). * UE can be configured with multiple CSI-ResourceConfigs.“ |
| QCOM5 | The background is the interpretation of the current spec. We don’t see the motivation for the technique as is spelled out. Hence, we don’t think it is needed. |
| Samsung | We are generally fine with the proposal. We suggest considering all three types of adaptation under technique #C-1.  Please find our additions/deletions below:   * Technique #C-1: Dynamic adaptation of spatial elements   + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving ~~UE-specific~~ channels and signals.   + Potential enhancements related to spatial element adaptation may be indicated to the UEs and mechanisms to trigger gNB to switch between different spatial domain configurations may be considered.   + Adaptation can be further categorized into ~~two~~ following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).     - Type 3: activate/deactivate all spatial elements of a RS configuration   Type 1, Type 2 and Type 3 should also consider power adaptation on the spatial elements associated with the antenna ports/RS configuration. |
| DOCOMO | Generally, we are fine with FL’s updated proposal.  For the impact to other WG, similar as proposal 5-1D, the impact to mobility should be considered.   * + Potential impact to other WG     - RAN2: Impact on mobility due to dynamic spatial adaptation of CSI-RS/SSB [RAN2, RAN3]     - RAN3:     - RAN4:       * RLM or RRM measurement from adaptation changes to antenna ports configuration. |
| Ericsson3 | We propose below updates. At least from our perspective, many of the detailed such as background/types, are not needed for other WGs, at least at this point, and hence those aspects could be captured in the subsequent detailed description of the techniques. What we could add for other WGs is that the enhancements may include enhanced CSI-RS configurations, CSI measurements and feedback.   * Technique #C-1: Dynamic adaptation of spatial elements   + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving UE-specific channels.   + Potential enhancements related to spatial element adaptation may be indicated to the UEs and mechanisms to trigger gNB to switch between different spatial domain configurations may be considered, including enhanced CSI-RS configuration, CSI measurements and feedback.   + Background:   + Potential impact to other WG     - RAN2:     - RAN3:     - RAN4:       * RLM or RRM measurement from adaptation changes to antenna ports configuration.     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| Intel | Minor revisions suggested for the background   * + Background:     - According to legacy procedure, adaptation of spatial elements can be done by updating configuration in a semi-static manner. Dynamic adaptation of spatial elements may have higher potential in achieving energy saving gain and is a technique that allows the gNB to dynamically turn on/off some active transceiver chains or spatial elements. The technique should be applicable to PDSCH/PUSCH. Besides, The technique may be applicable to reference signals (e.g. CSI-RS) and/or broadcast channels/signals (e.g., SSB/SI/paging)Section 5.2.1.4 in 38.214 addresses the CSI-RS Resource configuration. |
| Huawei, HiSilicon | We don’t see critical aspect that needs other WGs involvement. |

#### Proposal #4-2D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #C-2: TRP muting in multi-TRP operation
  + For a UE configured with multiple TRPs, TRP on/off can be informed to the UE.
  + The technique aims to dynamically adapt the number of active TRPs in transmitting and/or receiving UE-specific channels. It may include the adaptation of the spatial elements across active TRPs.
  + Background:
    - In Rel-17 NR, when two CSI resource sets are configured in a CSI report setting for Rel-17 group based beam reporting, UE cannot report the best N beams for each TRP/antenna panel independently.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #C-2: Dynamic adaptation of TRPs in mTRP
  + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
  + Potential specification impact:
    - Technique may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, single-DCI based scheduling, multi-DCI based scheduling, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc
    - Signaling details to indicate muted TRP, e.g., based on TRP index or CORESET pool index
    - Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - Enhancements to CSI measurement and feedback,
    - L1/L2 signalling to inform UE on update for TRP-related parameters due to dynamic TRP on/off.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals especially when the adaptation of the spatial elements is applied across active TRPs.
    - It is desired that enhanced beam reporting maintains same or similar configuration signaling overhead and measurement time compared to Rel-17 group based beam reporting.

#### Company Comments on Proposal #4-2D

|  |  |
| --- | --- |
| Company | Comments |
| CATT | We are OK with the proposal |
| Nokia/NSB | We wonder if we need to be ‘limiting’ the description at this stage by saying “UE-specific channels”? A better formulation could be:   * The technique aims to dynamically adapt the number of active TRPs in transmitting and/or receiving ~~UE-specific~~ signals and channels. It may include the adaptation of the spatial elements across active TRPs. |
| Lenovo | OK with the proposal. |
| QCOM5 | The background does not seem correct. Per our understandings, R17 CSI framework for mTRP has option to configure UE to provide the CSI report for each TRP as well as across TRP.   * + Background:     - ~~In Rel-17 NR, when two CSI resource sets are configured in a CSI report setting for Rel-17 group based beam reporting, UE cannot report the best N beams for each TRP/antenna panel independently.~~ |
| Samsung | We are fine with the proposal.  Suggest minor rewording as follows:   * Technique #C-2: TRP muting/adaptation in multi-TRP operation   + For a UE configured with multiple TRPs, TRP ~~on/off~~ activation/deactivation/adaptation can be informed to the UE.   The technique aims to dynamically adapt the number and spatial configuration of ~~active~~ TRPs ~~in~~ transmitting and/or receiving ~~UE-specific~~ channels and signals. It may include the adaptation of the spatial elements across active TRPs. |
| Huawei, HiSilicon | We don’t see critical aspect that needs other WGs involvement. |

### [ACTIVE] 4th Round Discussions

#### Proposal #4-1D

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #C-1: Dynamic adaptation of spatial elements
  + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.
  + Potential enhancements related to spatial element adaptation may be indicated to the UEs and mechanisms to trigger gNB to switch between different spatial domain configurations may be considered, including enhanced CSI-RS configuration, CSI measurement and feedback
  + ~~Adaptation can be further categorized into following types:~~
    - ~~Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource.~~
    - ~~Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).~~
    - ~~Note: May need to consider power adaptation on the spatial elements associated with the antenna ports/RS configuration~~
  + Background:
    - ~~According to legacy procedure, adaptation of spatial elements can be done by updating configuration in a semi-static manner. Dynamic adaptation of spatial elements may have higher potential in achieve energy saving gain and is a technique that allows the gNB to dynamically turn on/off some active transceiver chains or spatial elements. The technique may be applicable to PDSCH/PUSCH. reference signals (e.g. CSI-RS) and/or broadcast channels/signals (e.g., SSB/SI/paging)~~
    - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.
  + Potential impact to other WG
    - RAN2:
      * Signaling to trigger the change of spatial element configuration to UEs. Impact on mobility due to dynamic adaptation of spatial elements on CSI-RS/SSB
      * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.
    - RAN3:
      * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.
    - RAN4:
      * RLM or RRM measurement from adaptation changes to antenna ports configuration.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #4-1F

* Technique #C-1: Dynamic adaptation of spatial elements
  + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.
  + Potential enhancements include spatial element adaptation may be indicated to the UEs and mechanisms to trigger gNB to switch between different spatial domain configurations may be considered, including enhanced CSI-RS configuration, CSI measurement and feedback
  + Background:
    - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.
  + Potential impact to other WG
    - RAN2:
      * Signaling to trigger the change of spatial element configuration to UEs.
      * Impact to mobility due to dynamic spatial adaptation of CSI-RS.
    - RAN3:
    - RAN4:
      * RLM or RRM measurement from adaptation changes to spatial element configuration.

#### Proposal #4-1G

* Technique #C-1: Dynamic adaptation of spatial elements
  + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.
  + Potential enhancements include the mechanisms to indicate spatial element adaptation to the UEs and the mechanisms to trigger gNB to switch between different spatial domain configurations, including e.g., enhanced CSI-RS configuration, CSI measurement and feedback, signaling for the spatial element adaptation for SSB.
  + Background:
    - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.
  + Potential impact to other WG
    - RAN2:
      * Signaling to trigger the change of spatial element configuration to UEs.
      * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.
    - RAN3:
    - RAN4:
      * RLM or RRM measurement from adaptation changes to spatial element configuration.

#### Proposal #4-1H

* Technique #C-1: Dynamic adaptation of spatial elements
  + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.
  + Potential enhancements include the mechanisms to indicate spatial element adaptation to the UEs and the mechanisms to trigger gNB to switch between different spatial domain configurations, including e.g., enhanced CSI-RS configuration, CSI measurement and feedback, signaling for the spatial element adaptation for SSB.
  + Background:
    - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.
    - CSI-RS and CSI reporting configurations are BWP-specific, and BWP adaptation frame-work can be utilized for the adaptation.
  + Potential impact to other WG
    - RAN2:
      * Signaling to trigger the change of spatial element configuration to UEs.
      * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.
    - RAN3:
    - RAN4:
      * RLM or RRM measurement from adaptation changes to spatial element configuration.

#### Company Comments on Proposal #4-1E/F/G

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| --- | --- |
| Company | Comments |
| LG Electronics | We are not so sure if SSB uggeston is included in this technique. If not, we can remove SSB in potential impact to other WG, as follows.   * + Potential impact to other WG     - RAN2:       * Signaling to trigger the change of spatial element configuration to UEs.       * Impact to mobility due to dynamic spatial adaptation of CSI-RS.     - RAN3:       * Impact to mobility due to dynamic spatial adaptation of CSI-RS.     - RAN4:       * RLM or RRM measurement from adaptation changes to antenna ports configuration. |
| DOCOMO | From our understanding, it is better to provide the category information of Type 1, Type 2 and Type 3 for other WGs to understand what kind of spatial adaptation that RAN1 will consider.  But if the simplified version is target for sharing with other WGs, and it is with majority of view, we are fine with current version. |
| ZTE, Sanechips | Minor suggestions as below for better readability.   * Technique #C-1: Dynamic adaptation of spatial elements   + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.   + Potential enhancements include ~~related to~~ spatial element adaptation may be indicated to the UEs and mechanisms to trigger gNB to switch between different spatial domain configurations may be considered, including enhanced CSI-RS configuration, CSI measurement and feedback   + Potential impact to other WG   [comments] the two highlights are duplicated.   * + - RAN2:       * Signaling to trigger the change of spatial element configuration to UEs. Impact on mobility due to dynamic adaptation of spatial elements on CSI-RS/SSB       * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.   [comments] the following bullet seems no impact on RAN3. It can be removed.   * + - RAN3:       * ~~Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.~~   [comments] update for consistent terminology.   * + - RAN4:       * RLM or RRM measurement from adaptation changes to spatial element ~~antenna ports~~ configuration. |
| Samsung | We are fine with the proposal as it stands. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Updated proposal to #4-1F based on comments. |
| Apple | We actually think SSB should be considered. It is unclear to us how the adaptation can be done e.g. if the number of active transceiver chains is changed and SSB stays unchanged. We propose that SSB is added.   * + The technique aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.   + Potential enhancements include the mechanisms to indicate spatial element adaptation to the UEs and the mechanisms to trigger gNB to switch between different spatial domain configurations, including e.g. enhanced CSI-RS configuration, CSI measurement and feedback, signaling for the spatial element adaptation for SSB.   On RAN2 impact   * + - * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB. |
| Moderator | Updated |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
| Mediatek | * On **Technique #C-1: Dynamic adaptation of spatial elements**, we would like to point out the configurations of CSI-RS and CSI reporting are BWP specific. For dynamic adaptation, BWP adaptation framework can be utilized based on current specification. In this regard, we would suggest the following update:  |  | | --- | | * + Background:     - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.     - CSI-RS and CSI reporting configurations are BWP-specific, and BWP adaptation framework can be utilized for the adaptation.   + Potential impact to other WG     - RAN2:       * Common Signaling to trigger the change of spatial element configuration to UEs.       * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB. | |
| Moderator | Updated to #4-1H.  For the impact, I think there is no need to add the word common. Signaling should be generic enough. |
| LG Electronics | Similar to Proposal #2-2H, we suggest to add some more wording, as follows.   * + Background:     - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.     - CSI-RS and CSI reporting configurations are BWP-specific, and BWP adaptation frame-work can be utilized for the adaptation for a UE capable of multiple BWPs and dynamic BWP switching. |

#### Proposal #4-2D

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #C-2: TRP muting/adaptation in multi-TRP operation
  + For a UE configured with multiple TRPs, TRP activation/deactivation/adaptation can be informed to the UE.
  + The technique aims to dynamically adapt the number and spatial configuration of TRPs transmitting and/or receiving signals and channels. It may include the adaptation of the spatial elements across active TRPs.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #4-2F

* Technique #C-2: TRP muting/adaptation in multi-TRP operation
  + For a UE configured with multiple TRPs, TRP activation/deactivation/adaptation can be informed to the UE.
  + The technique aims to dynamically adapt the number and spatial configuration of TRPs transmitting and/or receiving signals and channels.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:

#### Proposal #4-2G

* Technique #C-2: TRP muting/adaptation in multi-TRP operation
  + For a UE configured with multiple TRPs, TRP activation/deactivation can be informed to the UE. The technique aims to dynamically adapt the number of TRPs transmitting and/or receiving signals and channels.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:

#### Company Comments on Proposal #4-2E/F/G

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | Can someone explain what the highlighted part below means?  Unless it is clarified, we suggest to remove that sentence.   * + For a UE configured with multiple TRPs, TRP activation/deactivation/adaptation can be informed to the UE.   + The technique aims to dynamically adapt the number and spatial configuration of TRPs transmitting and/or receiving signals and channels. It may include the adaptation of the spatial elements across active TRPs. |
| DOCOMO | We are fine with FL’s summary. |
| Samsung | We are fine with the proposal as it stands. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Removed the highlighted text from LGE’s comments. Updated to Proposal #4-2F. |
| Apple | On adapting “spatial configuration” of TRPs, we wonder how it is different from C-1. We suggest that we focus on the adaptation on the number of TRPs here, and the spatial configuration adaptation can be covered by C-1. Of course the two techniques can be potentially combined/used together.   * Technique #C-2: TRP muting/adaptation in multi-TRP operation   + For a UE configured with multiple TRPs, TRP activation/deactivation can be informed to the UE.   + The technique aims to dynamically adapt the number of TRPs transmitting and/or receiving signals and channels. |
| Moderator | Moderator tends to agree with Apple’s comment. C-1 seems to be genertic enough to also cover TRP adaptation as well. Let’s remove this for now. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
|  |  |

#### Other Aspects (not part of agreement)

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

##### Technique #C-1: Dynamic adaptation of spatial elements

* + Adaptation can be further categorized into following types:
    - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource (set).
    - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).
    - Note: May need to consider power adaptation on the spatial elements associated with the antenna ports/RS configuration
  + Potential enhancements to UE behaviors due to dynamic port adaptation, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.
    - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.
  + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses
  + UE feeds back indication to trigger spatial element adaptation
  + Potential specification impact:
    - The related changes in spatial domain caused by spatial element adaptation should be indicated/configured to the UEs for the spatial adaptation of gNB/cell power state. Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Type 1 and Type 2, and Type 3 may have impact on measurement operation (if dynamic spatial elements adaptation will impact CSI-RS, SSB ...), so the potential enhancement may include
    - CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements, e.g. UE behavior enhancement.
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Enhanced CSI measurement/reporting to support multiple CSI-RS resource measurement/reporting
    - Dynamic adaptation of spatial elements may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Signaling details to indicate changes of the number of active transceiver chains or spatial elements
    - Enhancements to CSI measurement and feedback, BRF, RLM, and RRM.
    - Support L1/L2 signalling to inform UE on parameter configurations (e.g., downlink power allocation, TCI state, RS for path loss measurement etc.) to be used with respect to the spatial parameter change.
    - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Introduction of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - CSI-RS/reporting reconfiguration to UEs for dynamic adaptation of spatial elements.
    - Optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS within an active configuration.
      * Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs and indicating change by UE-specific/UE-group common signaling.
      * This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc
    - UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB
  + Additional consideration/aspects (including any impact to legacy UEs, if any)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, if the technique is applied to the broadcast channels and signals, approaches such as power boosting should be considered to guarantee cell coverage.
    - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.

##### Technique #C-2: Dynamic adaptation of TRPs in mTRP

* + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
  + Potential specification impact:
    - Technique may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, single-DCI based scheduling, multi-DCI based scheduling, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc
    - Signaling details to indicate muted TRP, e.g., based on TRP index or CORESET pool index
    - Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - Enhancements to CSI measurement and feedback,
    - L1/L2 signalling to inform UE on update for TRP-related parameters due to dynamic TRP on/off.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals especially when the adaptation of the spatial elements is applied across active TRPs.
    - It is desired that enhanced beam reporting maintains same or similar configuration signaling overhead and measurement time compared to Rel-17 group based beam reporting.

#### Company Comments on other aspects

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| --- | --- |
| Company | Comments |
| Samsung | We are fine with the additional description portion for techniques #C-1 and #C-2. We would just like to propose the below addition:   * + Adaptation can be further categorized into following types:     - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource (set).     - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).   Note: May need to consider power adaptation on the spatial elements associated with the antenna ports/RS configuration |
| Moderator | Added suggestion from Samsung. |

### == Summary of 4th Round Discussions ==

The proposals are getting more stable. Here are the updates proposals for spatial domain techniques. Moderator suggests agreeing the following proposal.

#### Proposal #4-1H

* Technique #C-1: Dynamic adaptation of spatial elements
  + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.
  + Potential enhancements include the mechanisms to indicate spatial element adaptation to the UEs and the mechanisms to trigger gNB to switch between different spatial domain configurations, including e.g., enhanced CSI-RS configuration, CSI measurement and feedback, signaling for the spatial element adaptation for SSB.
  + Background:
    - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.
    - CSI-RS and CSI reporting configurations are BWP-specific, and BWP adaptation frame-work can be utilized for the adaptation.
  + Potential impact to other WG
    - RAN2:
      * Signaling to trigger the change of spatial element configuration to UEs.
      * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.
    - RAN3:
    - RAN4:
      * RLM or RRM measurement from adaptation changes to spatial element configuration.

#### Proposal #4-2G

* Technique #C-2: TRP muting/adaptation in multi-TRP operation
  + For a UE configured with multiple TRPs, TRP activation/deactivation can be informed to the UE. The technique aims to dynamically adapt the number of TRPs transmitting and/or receiving signals and channels.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:

## 2.5 Power-domain based Energy Saving Techniques

* [3] Nokia, NSB
  + Proposal-18: Considering enhancing the configuration of the power offset between PDSCH and NZP CSI-RS to assist NW energy saving operation.
  + Proposal-19: To minimize the impact on MIMO performance, the CSI report from UE can be extended to assist the network for adjustment of the transmission power and/or bandwidth assignment.
  + Observation-10: The role of UE feedback and possible RAN1 relevance for the adaptation of digital pre-distortion by the gNB, use of digital post-distortion by the UE and adaptation of transceiver filtering operation requires further clarification.
  + Observation-11: The use of tone reservation together with DFT-s-OFDM in uplink might enable lower PAPR, however the complexity of using tone reservation on top of CP-OFDM in downlink requires further study.
* [5] vivo
  + Proposal 14: The benefit of adaptation of transmission power of signals and channels need to be clarified and evaluated.
  + Observation 8: PA efficiency enhancement at BS side (e.g., ET and DPD) can be achieved by BS implementation without spec impact.
  + Proposal 15: The benefit of spec-involving BS PA efficiency enhancement technique compared to implementation-based scheme (ET and DPD) should be clarified at cost of UE complexity.
* [8] CATT
  + Observation 17: In case of support of low transmission power, static power consumption of PA/RF and low PA efficiency could degrade network energy saving gain significantly.
  + Observation 18: Compared with RF chains ON/OFF adaptation in spatial domain, dynamic adjustment of gNB’s transmission power has limited energy saving gain.
  + Proposal 23: The power scaling of the DL Tx power variation in NES power model should be determined for identifying the NES technique in power domain.
  + Observation 19: Digital pre-distortion technique could increase the PSD of DL link and the DL coverage but provide limited impact in gNB power consumption.
* [10] Intel
  + Observation 7: Transmission power adaptation in some situations does result in reduction in power consumption anywhere between 15% to 30% at the expense of some cell/user throughput. In the right circumstances, it might be beneficial for the network to be able to update the transmission power such that all UEs can be aware of the update efficiently.
  + Proposal 5: Consider support of more efficient signaling methods to update the transmission power (offset) of CSI-RS. This includes transmission power offset between CSI-RS and SSB, and CSI-RS and PDSCH.
* [11] Lenovo
  + Proposal 10: Consider supporting multiple SSB burst configurations in a cell, where each SSB burst configuration corresponding to one network node within the cell includes separately configured SSB positions in burst and SSB transmit power.
  + Proposal 11: Include the following texts in TR38.864
    - Technique #D-1: Adaptation of transmission power of signals and channels
      * Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power.
    - Analysis for technique #D-1:
      * Some network nodes within a cell reduce SSB transmission power (including turning off) for energy saving.
    - Spec impact for technique #D-1:
      * Support of multiple SSB burst configurations in a cell to allow each network node within a cell to set SSB transmission power separately.
* [12] ZTE, Sanechips
  + Fixed DL transmission power cannot adapt to requirements of NW power saving, UE power saving and interference management.
  + Dynamic power adjustment can help UE and gNB power saving and keeps performance impact under control.
  + 9.4%~21% network energy saving gain is observed in the case RU=10%~40% when NW transmission power is reduced by 3dB.
  + More dynamic DL power allocation and information reported by UE can be considered for NW ES in power domain.
  + Dynamic DL power control for reference signal can be considered for NW ES in power domain.
  + The following aspects for power domain adaptation techniques should be captured in the TR
    - Feature description for adaptation of transmission power of reference signals/channels
      * Dynamic power control, e.g., dynamically reducing the transmission power or PSD of signals and channels, e.g. SSB, CSI-RS, PDSCH
      * UE feedback/report power information, e.g., CSI reporting, power adjustment indication, etc.
    - Performance impacts:
      * Energy saving gains, UPT loss, and other evaluation metrics by adaptation of transmission power
    - Specification impacts:
      * Indication of power adaptation, e.g., via DCI or MAC CE
      * UE feedback information, e.g., CSI reporting, power adjustment indication
      * Co-existence issue or any other spec impacts
* [14] CMCC
  + Proposal 21: To reduce initial access impact for legacy UEs, SSB transmission with lower power for some occasions can be considered.
  + Proposal 22: Dynamic indication of powerControlOffsetSS can be applied for the adaptation of CSI-RS transmission power.
  + Proposal 23: Dynamic indication of powerControlOffset can be applied for the adaptation of PDSCH transmission power.
  + Proposal 24: CSI reporting enhancement can be considered for gNB to adjust DL transmission power.
  + Proposal 25: Technique aspects related to power domain are summarized as follows:
    - Technique #D-1: Adaptation of transmission power of signals and channels
      * Network energy savings could be potentially obtained by reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.
        + Specification impact: signaling of SSB transmission power pattern, signaling of modified power ratio between CSI-RS and PDSCH or between SSB and CSI-RS to provide adaptation of flexible power ratio values.
      * Network energy savings could be potentially obtained by transmission power adaptation with UE feedback information.
        + Specification impact: multiple CSIs in one CSI reporting to feedback DL transmission power recommendations to gNB.
* [16] LGE
  + Proposal #12: Investigate impacts of power adaptation for SSB and/or NZP CSI-RS if transmit power for SSB and/or NZP CSI-RS can be dynamically changed.
* [17] Mediatek
  + Observation 7: For the NW scenario with light load (15% - 30%), reducing PSDCH power/PSD-level by 6dB can bring 17% NW energy saving gain for Cat 1 BS and Cat 2 BS, subject to 6% increment in average data packet latency. On the other hand, further power/PSD-level reduction brings ≤1% additional energy saving gain while causing ≥6% data latency increment.
  + Observation 8: For the NW scenario with medium load (30% - 50%), reducing PSDCH power/PSD-level by 6dB can bring ≥26% NW energy saving gain for Cat 1 BS and Cat 2 BS, subject to 10% increment in average data packet latency. On the other hand, further power/PSD-level reduction brings ≤3% additional energy saving gain while causing ≥14% data latency increment.
  + Proposal 10: Reducing PDSCH power/PSD-level by a limited factor is recommended for network energy saving.
  + Proposal 11: Further investigate how to extend BWP framework to accommodate changing PDSCH power/PSD-level in a UE-group-specific or cell-specific manner.
  + Proposal 12: If agreed, LS to request RAN4 for providing suggested power consumption scaling for PA related transceiver processing enhancements. Meanwhile, RAN1 can discuss the feasibility of UE support for the schemes.
  + Observation 9: From UE feasibility point of view, “channel aware tone reservation that decrease PAPR” is more feasible than other transceiver processing enhancements because of UE can provide the additional information to BS along legacy CSI measurement and reporting operations.
* [18] Apple
  + Technique #D-1: Adaptation of transmission power of signals and channels
    - Network energy savings could be potentially obtained by reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.
      * Support of signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS are expected to provide adaptation of flexible power ratio values and potentially reduce overhead, e.g. by utilizing group-level or cell common signaling.
      * This may include enhancements on CSI-RS based measurements, such as beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
    - The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
    - Network energy savings could be potentially obtained by transmission power adaptation with UE feedback information, e.g, CSI reporting, power adjustment indication, etc.
    - ~~Dynamic adaptation of power offset(s) between PDSCH and CSI-RS.~~
    - The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.
      * [Comment] This sentence needs rephrasing.
    - This will impact legacy UEs if the transmission power of common signals/channels is adapted.
  + Technique #D-2: enhancements to [gNB digital pre-distortion] and UE post-distortion
    - Transmission energy efficiency at the network can be potentially improved with use of [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
      * Whether and how much improvement of the PAE (power-added efficiency) should be disclosed.
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
    - [Comment] This should be discussed in RAN4.
  + Technique #D-3: adaptation of transceiver processing algorithm
    - Transmission energy efficiency at the network can be potentially improved with use of techniques such as channel aware tone reservation that decrease PAPR.
      * The UE must be notified of the sub-carriers carrying the TR signal, as using existing patterns (e.g., CSI-RS) is not practical
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption. Different transceiver processing algorithms at the gNB should be transparent to the UE.
    - Power model for the scaling of different transceiver processing algorithm should be provided with justification.
    - [Comment] This should be discussed in RAN4.
  + Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
    - Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.
    - The PA energy consumption consists around ~70 % of the energy consumed at the BS.
    - The majority of this energy consumed at the PA is due to the input power bias (“backoff”).
    - In some cases, especially when the cell and neighbor cells are almost empty, reducing this input power bias (“backoff”) results in significantly lower energy consumption.
    - This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated.
    - With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band.
    - With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells.
    - In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.
    - The effect of PAE to the scheme should be disclosed.
    - [Comment] This should be discussed in RAN4.
* [21] Panasonic
  + Proposal 4: gNB power domain adaptation for energy saving can possible be controlled by the frequency and antenna domain adaptation. The adaptation of Tx power of different channels without impacting coverage may possibly work without specification impact so can be down prioritized. PA efficiency related discussion may involve RAN4 expertise, if necessary.
* [22] Interdigital
  + Proposal 4: Capture the following in TR38.864 (changes from R1-2208185 indicated in red):

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| Power Domain Techniques   * Technique #D-1: Adaptation of transmission power of signals and channels   + Network energy savings could be potentially obtained by reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.     - Support of signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS are expected to provide adaptation of flexible power ratio values and potentially reduce overhead, e.g. by utilizing group-level or cell common signaling.     - This may include enhancements on CSI-RS based measurements, such as beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure   + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.   + Network energy savings could be potentially obtained by transmission power adaptation with UE feedback information, e.g, CSI reporting, power adjustment indication, etc.   + Dynamic adaptation of power offset(s) between PDSCH and CSI-RS.   + The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model. * Technique #D-2: enhancements to assist ~~[~~gNB digital pre-distortion~~]~~ and UE post-distortion   + Transmission energy efficiency at the network can be potentially improved with use of [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.     - Whether and how much improvement of the PAE (power-added efficiency) should be disclosed.   + In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals   + In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.   + Specification impacts may include reporting information for gNB digital pre-distortion assistance, and indication to the UE of whether it needs to apply non-linear equalization for a transmission. * Technique #D-3: adaptation of transceiver processing algorithm   + Transmission energy efficiency at the network can be potentially improved with use of techniques such as channel aware tone reservation that decrease PAPR.     - The UE must be notified of the sub-carriers carrying the TR signal, as using existing patterns (e.g., CSI-RS) is not practical   + gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption. Different transceiver processing algorithms at the gNB should be transparent to the UE.   + Power model for the scaling of different transceiver processing algorithm should be provided with justification. * Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation   + Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.   + The PA energy consumption consists around ~70 % of the energy consumed at the BS.   + The majority of this energy consumed at the PA is due to the input power bias (“backoff”).   + In some cases, especially when the cell and neighbor cells are almost empty, reducing this input power bias (“backoff”) results in significantly lower energy consumption.   + This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated.   + With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band.   + With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells.   + In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.   + The effect of PAE to the scheme should be disclosed. |

* [23] Samsung
  + Proposal 25: Support dynamic adaptation of downlink PSD and associated UE measurement procedure.
  + Observation 4: For a given data rate (low to medium), a combination of power and frequency domain adaptation would provide a balance between energy saving and system performance.
  + Proposal 26: Support joint adaptation of gNB transmission bandwidth and power spectral density.
  + Proposal 27: Consider the following changes to the TP for TR
    - Technique #D-1: Adaptation of transmission power of signals and channels
      * Network energy savings could be potentially obtained by reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.
        + Support of signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS are expected to provide adaptation of flexible power ratio values and potentially reduce overhead, e.g. by utilizing group-level or cell common signaling.
        + This may include enhancements on ~~CSI-RS based~~UE measurements, such as beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
      * The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
      * Network energy savings could be potentially obtained by transmission power adaptation with UE feedback information, e.g, CSI reporting, power adjustment indication, etc.
      * Dynamic adaptation of power offset(s) between PDSCH and CSI-RS.
      * The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.
    - [Technique #D-2: enhancements to [gNB digital pre-distortion] and UE post-distortion
      * Transmission energy efficiency at the network can be potentially improved with use of [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
        + Whether and how much improvement of the PAE (power-added efficiency) should be disclosed.
      * In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
      * In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.]
    - [Technique #D-3: adaptation of transceiver processing algorithm
      * Transmission energy efficiency at the network can be potentially improved with use of techniques such as channel aware tone reservation that decrease PAPR.
        + The UE must be notified of the sub-carriers carrying the TR signal, as using existing patterns (e.g., CSI-RS) is not practical
      * ~~gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.~~ Different transceiver processing algorithms at the gNB should be transparent to the UE.
      * Power model for the scaling of different transceiver processing algorithm should be provided with justification.]
    - [Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
      * Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.
      * ~~The PA energy consumption consists around ~70 % of the energy consumed at the BS.~~
      * ~~The majority of this energy consumed at the PA is due to the input power bias (“backoff”).~~
      * ~~In some cases, especially when the cell and neighbor cells are almost empty, reducing this input power bias (“backoff”) results in significantly lower energy consumption.~~
      * This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated.
      * With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band.
      * With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells.
      * ~~In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.~~
      * The effect of PAE to the scheme should be disclosed.]
* [24] Ericsson
  + Lowering the gNB output power for UEs in good coverage may have very limited impact on throughput.
  + UEs need to be aware of PDSCH power offset changes in relation to reference signals, otherwise the CSI reports and UE internal receiver settings may become invalid.
  + PDSCH power offsets to reference signals (CSI-RS), as well as power offset between CSI-RS and SSB are configured via RRC signalling which is rather slow.
  + Multiple power offset between PDSCH and CSI-RS, or CSI-RS and SSB can be configured to one NZP-CSI-RS resource and MAC-CE/DCI can be used to indicate which power offset to use for CSI measurement and report.
* [25] NTT Docomo
  + Proposal 6: For dynamic power adaptation on RS (such as SSB and CSI-RS) and channels (such as PDSCH), it is better to take down-selection for further investigation. Several key KPIs should be considered for this down-selection work.
    - Specification impact
    - Power saving effect
    - Cell discovery performance
* [26] Qualcomm
  + Observation 12: Dynamic transmit power adaptation could help gNB dynamically adapt PA operation for achieving network energy savings.
  + Proposal 10: Capture in TR the following description for dynamic downlink transmission power adaptation
    - Dynamic downlink transmission power adaptation is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique is not applicable to broadcast channels/signals (e.g., SSB/SI/paging).
    - Reducing the DL transmit power level can provide network energy savings. However, it negatively impacts UPT and coverage. For example, with Set 1 FR1 reference configuration, reducing the DL transmit power level from 55dBm to 52dBm provides 9% and 6% average network energy savings in low and light load scenarios, respectively. However, it reduces 10% and 16% average UPT in low and light load scenarios, respectively. Furthermore, the DL SINR at 5 percentile (i.e., cell edge users) is reduced by around 4dB in low load and 2.5dB in light load.
    - Specification impact may include enhancing physical layer procedures (e.g., CSI and/or downlink transmission power signalling framework) to efficiently support dynamic downlink transmission power adaptation for network energy savings with minimal impact to user experience.
  + Observation 13: OTA DPD increases the EVM at the transmitter by 2.5dB to 6dB based on the PA transmission power, increasing bits/Joule (one of the KPIs reducing network power consumption as explained at the beginning of this section).
  + Proposal 11: Study the over the air training digital pre distortions method (OTA DPD) for DPD at the gNB’s transmission chain.
  + Observation 14: DpoD increases the EVM at the transmitter by between 3dB and 8dB based on the PA transmission power and received SNR, increasing bits/Joule (one of the KPIs reducing network power consumption as explained at the beginning of this section).
  + Observation 15: DpoD increases the throughput between 10% and 25% in most received SNRs (using higher MCSs). This throughput increase is reflected in higher bits/Joule (one of the KPIs reducing network power consumption).
  + Proposal 12: Study DpoD (Digital post distortion) for increasing efficiency at the gNB’s transmitter.
  + Observation 16: Channel aware TR technique provides gain between 1dB and 3dB over no TR waveform in SNRs between -5 and 25 dBs, varying on the received SNR.
  + Proposal 13: study Channel Aware Tone Reservation technique that allows reduction of PAPR of the DL, using dynamic selection of subcarriers and method to notify the UEs.
  + Proposal 14: Capture in TR the following description for gNB power amplifier mechanism to reduce gNB energy consumption:
    - Power amplifier (PA) backoff reduction (“relaxation) in empty to low loaded scenarios.
    - RAN 1 to study the following:
      * Network energy savings obtained by gNB PA backoff adaptation.
      * Impact of gNB PA backoff adaptation onto system performance
* [27] ITRI
  + Proposal 4: The following aspects for adaptation of transmission power by the gNB can be considered:
    - Dynamic adaptation of transmission power according to the energy saving state(s) or sleep mode(s)
* [28] CEWiT
  + Proposal 10: Dynamically adapting the DL transmission power at gNB in specific set of frequency and time resources utilizing assistance information from the UE is supported.

### [CLOSED] 1st Round Discussions

Companies should start thinking about what potential techniques to capture and what information would be captured together with the techniques. Moderator suggests refining the technique description further based on what was discussed in RAN1 #110. Discussion should include any suggestions to splitting or merging the techniques listed.

Please comment further on the following proposals, including comments to address notes from the moderator below.

#### Proposal #5-1

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-1: Adaptation of transmission power of signals and channels
  + reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.
    - signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing group-level or cell common signaling.
    - This may include enhancements on CSI-RS based measurements, such as beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc.
  + The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model. (1)

Moderator notes:

* Note (1) Need to Clarify (enough to be able to be evaluated by companies)
  + It seems unclear whether this is part of the technique or part of modeling discussion.

#### Company Comments on Proposal #5-1

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| Company | Comments |
| DOCOMO | For Note (1), it is related to power modeling discussion. We suggest deleting it.  ~~The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.~~ ~~(1)~~ |
| Lenovo | We suggest including a scheme below under the first bullet:  Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell. |
| Vivo | For SSB, we don’t think it is reasonable to change SSB power for one cell dynamically. This may introduce coverage and measurement problem.  For CSI-RS, the power can be semi-statically changed by RRC re-configuration. The need to have more dynamical power change should be verified.  For PDSCH, the actual transmission power is determined by gNB so it can be already changed dynamically by implementation.  In general, the spec impact on adaptation of transmission power of signals and channels is not clear. |
| Nokia/NSB | We need to agree on the Adaptation of transmission power for common channels and signals, i.e., SSB and CSI-RS because such adaptations impact the cell coverage. We need to clarify on scenarios when such adaptations can be applied as compared to completely turning off the SSB beam or CSI-RS port. We see the need to clarify that one of the “specific scenarios” can be cell deactivation, and that we see a benefit in reducing the SSB power (fast) such that Idle mode UEs can reselect to other cells. |
| LG Electronics | Note (1): Agree with the moderator, we can remove the corresponding sub-bullet. |
| ZTE, Sanechips | The following minor suggestion is provided   * + reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, ~~during specific scenarios or situations.~~ |
| Huawei, HiSilicon | Provide some more description to make the technique clearer: Proposal #5-1  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #D-1: Adaptation of transmission power of signals and channels   + reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.     - signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing group-level or cell common signaling.     - This may include enhancements on CSI-RS based measurements, such as beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure   + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.   + UE feedback information to assist gNB downlink power adaptation, e.g, CSI reporting, power adjustment indication, etc.     - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report.   + The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model. (1) |
| Samsung | * Both SSB and CSI-RS impact UE measurements. Therefore, ‘enhancements on CSI-RS based measurements’ can be generalized into ‘enhancements on UE measurements’. * Note 1: it belongs to BS power consumption/scaling modeling.   We suggest the following update highlight yellow. Proposal #5-1  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #D-1: Adaptation of transmission power of signals and channels   + reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.     - signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing group-level or cell common signaling.     - This may include enhancements on ~~CSI-RS based~~ UE L1/L3 measurements and L3 filtering behavior due to power adaptation for ~~, such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure |
| Intel | More information is needed for the following two bullets:   * + UE feedback information, e.g, CSI reporting, power adjustment indication, etc.   + The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.   Also, we think it would be good to capture potential specification impact from power adjustment. For example, something like below:   * Potential specification impacts are:   + Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication. |
| CEWiT | The variation of DL may be dependent on the used resources for the transmission hence we suggest to update the Technique D-1 as follows,   * Technique #D-1: Adaptation of transmission power of signals and channels   + reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.     - signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing group-level or cell common signaling.     - This may include enhancements on CSI-RS based measurements, such as beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure     - This may include resource based variation of DL power for various signals & channels   + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.   + UE feedback information, e.g, CSI reporting, power adjustment indication, etc.   + The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model. (1) |
| QCOM1 | This should belong to discussion under power modelling.  It was agreed by most companies, that PA efficiency reduces with reduced transmission power and increases with increased transmission power. A linear scaling power model keeps the PA efficiency as high as in the nominal (full) transmission power, providing misleading (biased for the better) results.   * The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.   Power model must capture the nonlinear PA efficiency change with transmission power in order to evaluate correctly the power consumption |
| CATT | We agree with FL that this is the power scaling issue in the evaluation methodology. We can have description discussed once power scaling model is agreed and evaluation results with network energy saving gain is shown. |
| InterDigital | It is not clear to us why the sub-bullet on “Dynamic adaptation of power offset(s) between PDSCH and CSI-RS” is removed.  We think the sub-bullet should be retained for further discussion. |
| Ericsson1 | Our suggested updates are as follows (last bullet does describe a technique, but rather it is related to evaluation, as also mentioned by moderator)   * + reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH, during specific scenarios or situations.     - signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.     - This may include enhancements on CSI-RS based measurements, such as beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure   + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.   + UE feedback information, e.g, CSI reporting, power adjustment indication, etc.   + [The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model. (1)] |

#### Proposal #5-2

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-2: enhancements to [gNB digital pre-distortion] and UE post-distortion
  + [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
    - Whether and how much improvement of the PAE (power-added efficiency) should be disclosed.
  + In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
  + In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.

#### Company Comments on Proposal #5-2

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| Company | Comments |
| DOCOMO | We think it is gNB implementation issue. The necessity of RAN1 changing of Proposal #5-2 is not clear. |
| Vivo | PA efficiency enhancement at BS side (e.g., ET and DPD) can be achieved by BS implementation without spec impact. |
| Nokia/NSB | We agree with DOCOMO and vivo, and do not see any RAN1 impacts from this proposal. |
| Samsung | This belongs to implementation oriented solution. We can keep them for further RAN1 discussion, but we are not OK to capture this in the TR as is. At least, we suggest to put in square brackets. |
| Apple | We think this should not be discussed in RAN1. If there is interest, it should be discussed in RAN4. |
| CATT | We have reservation on Proposal #5-2. We also agree that this is more implementation issue and does not have RAN1 impact. |
| InterDigital | We suggest to slightly modify the description of Technique#D-2 to the following:   * Technique #D-2: enhancements to assist [gNB digital pre-distortion] and UE post-distortion   In our view, the description under Proposal #5-2 should be retained for further discussion in RAN1. We also suggest capturing the specification impacts of Technique#D-2 in Proposal #5-2 as follows:   * Specification impacts may include reporting information for gNB digital pre-distortion assistance, and indication to the UE of whether it needs to apply non-linear equalization for a transmission. |

#### Proposal #5-3

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-3: adaptation of transceiver processing algorithm
  + channel aware tone reservation that decrease PAPR.
    - The UE must be notified of the sub-carriers carrying the TR signal
  + gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption. Different transceiver processing algorithms at the gNB should be transparent to the UE.(2)
  + Power model for the scaling of different transceiver processing algorithm should be provided with justification.(3)

Moderator notes:

* Note (2) Need to Clarify (enough to be able to be evaluated by companies)c
  + belong to specification impact
* Note (3) Need to Clarify (enough to be able to be evaluated by companies)
  + Should this be discussed in power model?

#### Company Comments on Proposal #5-3

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| Company | Comments |
| DOCOMO | We think it is gNB implementation issue. The necessity of RAN1 changing of Proposal #5-3 is not clear. |
| Nokia/NSB | We agree with DOCOMO and do not see any RAN1 impacts from this proposal. We also agree that Note (3) could be discussed as part of power model. |
| Samsung | * This belongs to implementation oriented solution. We can keep them for further RAN1 discussion, but we are not OK to capture this in the TR as is. At least, we suggest to put in square brackets. * Removed unnecessary descriptions. * Note 2: it would be a gNB internal operation. * Note 3: same view as FL   We suggest the following update highlight yellow. Proposal #5-3  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #D-3: adaptation of transceiver processing algorithm   + channel aware tone reservation that decrease PAPR.     - The UE must be notified of the sub-carriers carrying the TR signal   + ~~gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.~~ Different transceiver processing algorithms at the gNB should be transparent to the UE.(2)   + Power model for the scaling of different transceiver processing algorithm should be provided with justification.(3) |
| QCOM1 | With regards to the BS transceiver adaptation algorithms and the need to inform the UE, the tone reservation technique has specification impact. The network needs to send the tones reserved either via DCI or MAC CE or RRC, hence eventually RAN 2 has to be involved as well.  It was agreed by most companies, that PA efficiency reduces with reduced transmission power and increases with increased transmission power. A linear scaling power model keeps the PA efficiency as high as in the nominal (full) transmission power, providing misleading results.   * Power model for the scaling of different transceiver processing algorithm should be provided with justification. * Power model must capture the nonlinear PA efficiency change with transmission power in order to evaluate correctly the power consumption |
| Apple | We think this should not be discussed in RAN1. If there is interest, it should be discussed in RAN4. |
| CATT | We believe that this is the implementation and does not have any specification impacts. We should not have discussed this. |
| InterDigital | We share similar understanding with QC on the potential specification impacts. We think the description under Proposal #5-3 should be retained for further discussion in RAN1. |
| Ericsson1 | This seems to be a gNB implementation based. At least clarifications indicated in moderator notes should be discussed further. |

#### Proposal #5-4

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
  + Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.
  + This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated. (4)
  + With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band. (4)
  + With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells. (4)
  + In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.(4)
  + The effect of PAE to the scheme should be disclosed.

Moderator notes:

* Note (4) Need to Clarify (enough to be able to be evaluated by companies)
  + Some refinement may be preferred to split these into: technique description part (needed to evaluate) and performance/impact analysis (to be analyzed after evaluations)

#### Company Comments on Proposal #5-4

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| Company | Comment |
| DOCOMO | We think it is gNB implementation issue. The necessity of RAN1 changing of Proposal #5-4 is not clear. |
| Samsung | * This belongs to implementation oriented solution. We can keep them for further RAN1 discussion, but we are not OK to capture this in the TR as is. At least, we suggest to put in square brackets.   We suggest the following update highlight yellow. Proposal #5-4  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation   + Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.   + This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated. (4)   + With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band. (4)   + With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells. (4)   + ~~In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.~~~~(4)~~   + The effect of PAE to the scheme should be disclosed. |
| QCOM1 | The technique can be described as followed:  In the case of no load or in case of low load in the cell and in neighbor cells, the BS decides to relax its PA “backoff”. PA “backoff” can be reduced by X dB. PA backoff reduction during typical PA operation points result in ~40% reduction in PA power consumption. In some cases, i.e. when the PA output power is low, then, the PA backoff adaptation does not result into perceived adjacent channel interference (ACI), Operating Band Unwanted Emissions(OBUE) or spurious OOB emissions. In cases of medium PA output power levels, the PA “backoff” relaxation might result into ACI, OBUE and spurious OOB emissions. Therefore, the BS about to perform PA backoff adaptation informs the neighbor BSs to pause any DL transmission, during the period when PA backoff will be adapted, so as DL transmission to UEs in neighbor carriers/bands/cells is not affected.   * In order to simulate the PA backoff adaptation scheme, what needs to be modeled is the impact onto UEs in neighboring bands, carriers for different levels of PA backoff adaptation. |
| Apple | We think this should not be discussed in RAN1. If there is interest, it should be discussed in RAN4. |
| CATT | This is also an implementation issue without any explicit indication of Network energy consumption. |
| Ericsson1 | This seems to be a gNB implementation based. At least clarifications indicated in moderator notes should be discussed further. |

### Summary of 1st Round Discussions

Based on feedback received moderator has updated the proposals as follows. Moderator suggest using the updated proposal for further discussions.

Notation of change marks above:

* Red Underline or ~~Stikethrough~~ Text: Updated text based on comments.
* Blue Underline Text: Updated text based on comments. However, moderator thinks further clarification is needed
* Green Text: Unchanged text. However, based on comments, moderator thinks further clarification is needed.

Proposal #5-1A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-1: Adaptation of transmission power of signals and channels
  + Reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH~~, during specific scenarios or situations~~.
    - signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
    - This may include enhancements on ~~CSI-RS based~~ UE L1/L3 measurements and L3 filtering behavior due to power adaptation, ~~such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
    - Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell.
    - This may include resource based variation of DL power for various signals & channels
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc, to assist gNB downlink power adaptation
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
  + Potential specification impacts are:
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
  + Additional aspects:
    - The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.

Several companies commented that Proposal #5-2A can be left up to implementation and therefore should not be the focus of the SI.

Proposal #5-2A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-2: enhancements to assist [gNB digital pre-distortion] and UE post-distortion
  + [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
    - ~~Whether and how much improvement of the PAE (power-added efficiency) should be disclosed.~~
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
  + Potential specification impacts are:
    - FFS

Several companies commented that Proposal #5-3A can be left up to implementation and therefore should not be the focus of the SI.

Proposal #5-3A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-3: adaptation of transceiver processing algorithm
  + channel aware tone reservation that decrease PAPR.
    - The UE must be notified of the sub-carriers carrying the TR signal
  + Background:
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Different transceiver processing algorithms at the gNB should be transparent to the UE.
  + ~~Power model for the scaling of different transceiver processing algorithm should be provided with justification.~~
  + Potential specification impacts are:
    - FFS

Several companies commented that Proposal #5-4A can be left up to implementation and therefore should not be the focus of the SI.

Proposal #5-4A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
  + Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.
  + Background:
    - This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated.
    - With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band.
    - With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells.
    - In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.
  + ~~The effect of PAE to the scheme should be disclosed.~~
  + Potential specification impacts are:
    - FFS

#### Proposal #5-1A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-1: Adaptation of transmission power of signals and channels
  + Reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH
    - signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
    - This may include enhancements on UE L1/L3 measurements and L3 filtering behavior due to power adaptation, ~~such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
    - Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell.
    - This may include resource based variation of DL power for various signals & channels
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc, to assist gNB downlink power adaptation
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
  + Potential specification impacts are:
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
  + Additional aspects:
    - The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.

#### Proposal #5-2A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-2: enhancements to assist [gNB digital pre-distortion] and UE post-distortion
  + [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
  + Potential specification impacts are:
    - FFS

#### Proposal #5-3A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-3: adaptation of transceiver processing algorithm
  + channel aware tone reservation that decrease PAPR.
    - The UE must be notified of the sub-carriers carrying the TR signal
  + Background:
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Different transceiver processing algorithms at the gNB should be transparent to the UE
  + Potential specification impacts are:
    - FFS

#### Proposal #5-4A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
  + Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.
  + Background:
    - This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated.
    - With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band.
    - With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells.
    - In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.
  + Potential specification impacts are:
    - FFS

### [CLOSED] 2nd Round Discussions

Based on discussion from GTW, we should split the discussion into two components. First aspect is regarding high level descriptions of the potential techniques, their potential specification impact, any impact to legacy UEs. The second aspect is providing even further details targeting providing information for evaluations.

#### Proposal #5-1B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-1: Adaptation of transmission power of signals and channels
  + Reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH
  + Background:
    - [To be filled]
  + Potential specification impacts are:
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-1: Adaptation of transmission power of signals and channels
  + signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
  + This may include enhancements on UE L1/L3 measurements and L3 filtering behavior due to power adaptation, ~~such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
  + Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell.
  + This may include resource based variation of DL power for various signals & channels
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc, to assist gNB downlink power adaptation
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report

#### Company Comments on Proposal #5-1B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | We suggest to remove the first bullet of specification impact since “group-based reconfiguration” is unclear and also suggest to remove PAE-related bullet since it should be discussed under 9.7.1   * + Potential specification impacts are:     - Signalling details to indicate the transmission power or PSD of DL signals and channels, e.g SSB, CSI-RS, PDSCH     - Enhancements on CSI/RRM measurements, beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure   + Additional considerations/aspects (including any impact to legacy UEs, if any): |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | The change of gNB power consumption is marginal with variation of Tx power. We could further discuss with evaluation results. |
| QCOM2 | We’ve provided our suggested update in green and red. Some comments for the update are provide in comment panel.   * Technique #D-1: Adaptation of transmission power of signals and channels   + The technique aims at adapting ~~Reducing~~ the transmission power or PSD of ~~various~~ downlink signals and channels.~~, e.g SSB, CSI-RS, PDSCH~~   + Background:     - [To be filled]   + Potential specification impacts are:     - Enhancements to CSI measurement and feedback     - Signalling to inform UE on the transmission power change     - ~~Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.~~   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - Downlink transmission power reduction may significantly impact the coverage of the cell, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.   ~~The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.~~  [Qualcom commented: Ongoing discussion in 9.7.1. No need to mention it here.] |
| Ericsson2 | We suggest below update for the paragraph under Potential specification impacts.   * Introduction of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication. |
| Lenovo | We suggest the following updates in blue:   * + Background:     - In NR, a cell can have only one SSB burst pattern, and all SSBs in a SSB burst have the same Tx power.   + Potential specification impacts are:     - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication. |
| DOCOMO | From our understanding, the RS power adaptation has the impacts on the L1 measurement results and then L3 measurement results. In this case, it may have the potential impact on the mobility procedure.   * + Potential impact to other WGS     - Impact on mobility due to dynamic power adaptation of CSI-RS/SSB [RAN2, RAN3] |
| Intel | For impact to other WGs, the following should be added   * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be needed. |
| Samsung | ‘The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model.’ Nothing to do with solution part and no need to be part of agreement. Suggest to remove |
| CMCC | Currently, the description of techniques and potential enhancements are mixed together. We suggest to move following text to “potential specification impact”:   * + Signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.   + Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report |
| CEWiT | We agree with LG Electronics for proposal #5-1B. |
| Huawei, HiSilicon | Based on the Chairman’s guideline, we have some comments/revisions on proposal #5-1B.  . Proposal #5-1B revised by HW Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #D-1: Adaptation of transmission power of signals and channels   + Reducing the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH   + Background:     - ~~[To be filled]~~ Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique will be applicable to PDSCH. Beside, the technique may be applicable to broadcast channels/signals (e.g., SSB/SI/paging).   + Potential specification impacts are:     - ~~Introduction of group-based reconfiguration~~ Configuration/re-configuration enhancement of various reference signal resources, measurement, reporting (if dynamic transmission power adaptation is applicable to reference signal resources)~~which may be RRC-based or MAC-CE based or by other physical layer indication~~.     - Need of UE assistant information, e.g.     - Enhanced CSI report, e.g. report multiple CSI, and each corresponds to a different power offset(hypothetical power offset between CSI-RS and PDSCH) in one CSI report, with corresponding CSI-RS/CSI report configuration enhancement     - power adjustment indication   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - The linear reduction of PAE (power added efficiency) when Tx power reduction should be included in the scaling of the power model. |
| Fujitsu | We are fine with LGE’s modifications. |
| ZTE, Sanechips | Suggestions are as below.   * Technique #D-1: Adaptation of transmission power of signals and channels   + Adaptation of ~~Reducing~~ the transmission power or PSD of various signals and channels, e.g SSB, CSI-RS, PDSCH   The following are suggested   * + Potential specification impacts are:     - Introduction of RRC-based or MAC-CE based or by other physical layer indication ~~group-based reconfiguration~~ of various reference signal resources, measurement, reporting, which may be ~~RRC-based or MAC-CE based or by other physical layer indication~~,group-based reconfiguration.     - Enhancement CSI measurement/report     - UE feedback information to assistance power backoff |
| Nokia/NSB | We suggest the following update for background information as presented in our Tdoc R1-2203225:   * + Background:     - [To be filled]   For 5G NR, the DL transmission power is defined in terms of energy per resource element (EPRE). As specified in TS38.214, a UE assumes that reception occasions of a physical broadcast channel (PBCH), PSS, and SSS are in consecutive symbols, as defined in [4, TS 38.211], and form a SS/PBCH block. And the UE assumes that SSS, PBCH DM-RS, and PBCH data have same EPRE. Practically, based on the output power of TRX(s), the network gNB may configure the DL transmitted EPRE of PBCH data, PBCH DM-RS, and SSS within a cell with the parameter ss-PBCH-BlockPower via ServingCellConfigCommon. Moreover, as specified in TS38.214, the UE may assume that the ratio of PSS EPRE to SSS EPRE in a SS/PBCH block is either 0 dB or 3 dB, meaning that practically if there is zero power offset or 0dB between EPRE of PSS and SSS, the EPRE of PSS could has the same value as ss-PBCH-BlockPower.  As specified in TS38.214, for the EPRE of non-zero power (NZP) CSI-RS, it is determined by the network configured parameter powerControlOffsetSS, which is a power offset, on top of the configured value of ss-PBCH-BlockPower. The value range of powerControlOffsetSS can be semi-statically configured of either -3db, 0db, 3db, or 6db according to TS38.331.  Practically, the EPRE of PDSCH, PDCCH, and PDCCH DM-RS depends on the number of scheduled PRBs (with the number of allocated resource elements) over the operating BW respectively. And for the case of 256QAM, the power backoff can be further applied for PDSCH transmission to compensate the non-linearity of PA in practice. Moreover, as specified in TS38.214, if the UE has not been provided with dedicated higher layer parameters, the UE may assume that the ratio of PDCCH DM-RS EPRE to SSS EPRE is within -8 dB and 8 dB when the UE monitors PDCCHs for a DCI format 1\_0 with CRC scrambled by SI-RNTI, P-RNTI, or RA-RNTI. And for downlink DM-RS with PDSCH, the UE may assume the ratio of PDSCH EPRE to DM-RS EPRE is according to the number of DM-RS CDM groups without data given by Table 4.1-1 in TS38.214. And when the UE is scheduled with PT-RS port(s) associated with the PDSCH, the ratio of PT-RS EPRE to PDSCH EPRE per layer per RE for each PT-RS port is given by Table 4.1-2 in TS38.214 according to the epre-Ratio if configured by higher layer. |

#### Proposal #5-2B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-2: enhancements to assist [gNB digital pre-distortion] and UE post-distortion
  + [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
  + Potential specification impacts are:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-2: enhancements to assist [gNB digital pre-distortion] and UE post-distortion
  + FFS

#### Company Comments on Proposal #5-2B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

Several companies commented that Proposal #5-2B can be left up to implementation and therefore should not be the focus of the SI. Moderator asks proponents can provide comments on this aspect.

|  |  |
| --- | --- |
| Company | Comments |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | This is an implementation issues We don’t see this is relevant to NES study. |
| QCOM2 | Additional description intended to aid evaluations (not part of agreement)   * Enhancements to assist [gNB digital pre-distortion] (**DPD-OTA)**:   + Justification: digital pre-distortion (DPD) operation requires coupling the Tx output to an Rx feedback chain to capture the non-linearity and estimate it. Beamformed multiple antennas designs, especially in higher bands (i.e., FR2), present new challenges making DPD training at Tx side difficult, as the receiver sees the composite equivalent non-linearity which is the result of all PA’s working in non-linear operating point and summed by the beamforming weighting. DPD needs to capture distortions on the far field beam and not per individual PA in order to account for cross coupling PA NL effects. These effects are not seen in DPD’s Tx coupling feedback   + Overview: UEs feedback DPD information based on their received signals. The UEs receive training signals in their respective beams, and process the information needed for gNB DPD. The computation schemes of the UE are vast, offering a range of performance and complexity tradeoff. One of them is calculation of the cross correlation of received signal after applying different non-linear kernels to it. The UEs will report the required information over a feedback channel. The gNB will then use the results for post-processing and calculating the DPD coefficients   + Specification impact:     - Capability of UEs to support DPD-OTA, activation of DPD process (measurement and reporting of enhanced CSI-RS)     - Configuration of a set of non-linear kernels by the NW     - Introduction of measurements and reporting of DPD information (e.g., non-linear kernels) to assist gNB’s DPD     - Enhancements to CSI-RS, such as transmission of nonlinear CSIRS (with low PAPR and higher transmit power), and possibly allocating a larger BW than the one consisting of the CSI-RS * UE digital post-distorsion (**DpoD**)   + Overview: Digital Post distortion (DpoD) is non-linear processing on the receiver side. The receiver might implement variety of techniques with various complexity and performance tradeoffs. For example, the UE might implement a post channel equalization non-linear equalization stage that will “invert” the non-linearity introduced by the power amplifier.   + Specification impact: The DpoD requires knowledge of the power amplifier model that can be obtained by signaling from the gNb to the UE   For clarity, we suggest splitting to two techniques (DPD-OTA and DpoD), each with own background, specification impacts and considerations and aspect:  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #D-2a: enhancements to assist [gNB digital pre-distortion] ~~and UE post-distortion~~   + ~~[Enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.~~   + Background:     - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals     - ~~In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.~~   + Potential specification impacts are:     - High level configuration (e.g., UEs capability, list of non-linear kernels, enhanced CSIRS)     - Introduction of measurements and reporting of DPD information (e.g., report best non-linear kernel out of a list)     - Introduction of CSI-RS enhancements (e.g., high power low PAPR transmission, rate matching around additional BW than the CSI-RS)   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - Legacy UEs are not aware of the new CSI-RS. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality * Technique #D-2b : UE post-distortion   + Background:     - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.   + Potential specification impacts are:     - High level configuration (e.g., UEs capability, list of power amplifier models)     - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality |
| Intel | For impact to other WGs, the following should be added   * Depending on the required change in BS RF requirements from relaxation of pre-distortions, inputs from RAN4 may be needed. * RAN4 input on potential UE requirements from support of post-distortion may be needed. |
| Apple | We still think this is a RAN4 issue, if there is interest. |
| InterDigital | We support Proposal #5-2B, and suggest to remove the [] brackets around gNB digital pre-distortion.  We also suggest capturing the following:   * Potential specification impact:   + Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission. |
| Nokia/NSB | As per our understanding, the PA and DPD adaptation are more significant in FR2.  The enhancements required for correction of the non-linearity of PA should be handled by the circuitry and the associated intelligence.  We should aim to keep the impact on the UE minimal and hence avoid any specification impact. |

#### Proposal #5-3B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-3: adaptation of transceiver processing algorithm
  + channel aware tone reservation that decrease PAPR.
    - The UE must be notified of the sub-carriers carrying the TR signal
  + Background:
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Different transceiver processing algorithms at the gNB should be transparent to the UE
  + Potential specification impacts are:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-3: adaptation of transceiver processing algorithm
  + FFS

#### Company Comments on Proposal #5-3B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

Several companies commented that Proposal #5-3B can be left up to implementation and therefore should not be the focus of the SI. Moderator asks proponents can provide comments on this aspect.

|  |  |
| --- | --- |
| Company | Comments |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | This is an implementation issue and not part of NES. |
| QCOM2 | Providing material on **Channel Aware Tone Reservation.**  Additional description intended to aid evaluations (not part of agreement)   * Technique #D-3: adaptation of transceiver processing algorithm   + Channel Aware tone Reservation     - Justification: Tone reservation is a known method that introduces specific tones in a subset of allocated sub-carriers to reduce the PAPR of a transmitted waveform. This PAPR reduction is used to reduce the power consumption of the gNB. Channel aware Tone Reservation exploits the channel nulls to carry those tones and provide additional 1-1.5dB gain over non channel aware TR (and a total of 2.5-3 dB gain over non-TR transmission).     - Overview: In order to support channel aware tone reservation, where the tones containing the TR signal are changing based on gNB’s decision, the UE receiver must be notified of the sub-carriers carrying the TR signal, and to rate match the data signal around the tones throughput all the symbols. The granularity of the tones is SCs (or several adjacent SCs) and can have several occurrences in frequency.   Due to channel aware tone reservation being the only technique with specific description, and due to uniqueness in the some of the attributes (e.g., can’t be transparent to the UE), we suggest handling it apart from the general description:  Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #D-3: adaptation of transceiver processing algorithm   + channel aware tone reservation that decreases PAPR.     - Background: Channel aware Tone Reservation exploits the channel nulls to carry TR tones, providing additional gain over non channel aware tone reservation. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes     - Potential specification impacts are either or both of:       * Introducing messaging to inform the UEs of the SCs carrying the TR signal, to be rate matched by the receiver (e.g., in DCI)       * Introducing enhancements on existing rate-matching patterns (e.g., PRB-symbol bitmaps, CSI-RS)     - Additional considerations/aspects (including any impact to legacy UEs, if any):       * Legacy UEs are not aware of the new rate matching patterns. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality   + Background:     - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.   + Different transceiver processing algorithms at the gNB should be transparent to the UE   + Potential specification impacts are:     - [To be filled]   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled] |
| Intel | For impact to other WGs, the following should be added   * If the proposal result in any significant changes to RF requirements either at gNB or UE, some inputs from RAN4 may be needed. |
| Apple | We still think this is a RAN4 issue, if there is interest. |
| Huawei, HiSilicon | Please find following some revisions:   * Technique #D-3: adaptation of transceiver processing algorithm   + [Huawei commented: “ channel aware” should be deleted. Whether TR is channel aware or not is up to gNB implementation.]   + ~~channel aware~~ tone reservation that decrease PAPR.     - The UE must be notified of the sub-carriers carrying the TR signal   + Background:     - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.   + Different transceiver processing algorithms at the gNB should be transparent to the UE   + Potential specification impacts are:     - [To be filled]   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - [To be filled]   + Potential impact to other WGS     - [To be filled] |
| InterDigital | We support Proposal #5-3B. We also suggest capturing the following:   * Potential specification impact:   + Signaling for providing tone reservation information to UE |
| QCOM4 | @ Huawei, HiSilicon:  Channel aware Tone reservation is different than Tone reservation.  The difference is that in channel aware Tone Reservation, **the dynamically selected tones need to be notified to the UEs for rate matching purposes**, whereas in regular tone reservation, the gNB can select the tones anywhere it chooses, and notification to the UEs may not be needed (provided gNB’s implementation of the scheduling with constraints).  To Summarize, **channel aware tone reservation** wording needs to stay unchanged, as a technique mandating signaling to the UEs as explained thoroughly in QCOM2 (in overview, background and Potential specification impacts), and also captured in Interdigital comment on Potential specification impact |

#### Proposal #5-4B

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
  + Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or very low load in the cell and in neighbor cells.
  + Background:
    - This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated.
    - With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band.
    - With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells.
    - In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.
  + Potential specification impacts are:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
  + FFS

#### Company Comments on Proposal #5-4B

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Text proposal to be used to fill in ‘background’, ‘potential specification impact’, and ‘additional consideration aspects’

Several companies commented that Proposal #5-4B can be left up to implementation and therefore should not be the focus of the SI. Moderator asks proponents can provide comments on this aspect.

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| Company | Comments |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | This is an implementation issue and not part of NES. |
| QCOM2 | The technique needs to change name: Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation |
| Intel | For impact to other WGs, the following should be added   * Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be needed. |
| Apple | We still think this is a RAN4 issue, if there is interest. |
| Huawei, HiSilicon | PA Input Power Bias (“input backoff”) Adaptation is activated only in case of zero or very low load. In zero load case, the gNB can go to sleep mode or shut off in order to save more energy. In very low load case, it is not clear how much additional unwanted in-band and out-of-band emission that UE can endure. If the UE cannot ensure any more additional unwanted in-band and out-of-band emission case by PA input power back-off relaxation. This technique cannot be activated even in a cell serving only one UE. So, this technique requires RAN4 expertise for further study. |
| QCOM3 | * Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation   + Technique(s) allowing to modify/reduce the input power bias (“input power backoff”) in cases of no or (very) low load in the cell and in neighbor cells.   + Background:     - This input power bias adaptation results in lower output PAPR, which is translated into some in band and out of band emissions being generated.     - With appropriate signal processing techniques, it is possible to “steer” the unwanted emissions either to the in-band signal or out-of-band.     - With suitable base station coordination and by steering the unwanted emissions onto carrier frequencies in which their impact can be traced, it is possible to avoid any eventual impact onto UEs in the cell or in neighbor cells.     - In general, this technique is activated only in case of zero or very low load in the cells; hence, the expectation is that no UEs will be affected by the generated in-band or out-of-band emissions.     - PA consumes 60 % to 70 % of the total power consumed at the BS. This PA power consumption is mainly due to high input bias (input voltage, or “backoff”) which is used in order for the PA to operate in the wanted operating region. By adapting the PA “backoff” value by few dB, the PA power consumption is reducing by 50% in the typical PA operating regions. This gain is significantly higher than the gain observed in most of the studied here techniques and therefore not to be ignored.     - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.     - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams     - For the scheme evaluation it is suggested to test the BS PA backoff adaptation of a single cell. E.g. by a reduction of X dB in the PA backoff value, Y dB of unwanted in-band emissions and Z dB of unwanted out-of-band emissions are generated. The impact of the BS PA backoff adaptation of a single cell into N neighbor cells with 1 up to K number of users per cell should be evaluated. The agreed simulation setup should be applied. Once the results of such evaluation are available, and an initial assessment of an eventual impact onto neighbor cells UEs is obtained and the network energy savings are obtained, then RAN 4 has to be contacted for a finer definition of requirements in terms of in-band and out-of-band unwanted emissions.   + Potential specification impacts are:     - Eventual UE measurement configurations assessing the impact from BS PA backoff adaptation     - BS unwanted in-band and out-of-band emissions exchange to neighbor BSs   + Additional considerations/aspects (including any impact to legacy UEs, if any):     - BS PA backoff adaptation should not be applied when SSB/SI is transmitted in the cell and in neighbor cells so as UEs in idle/inactive mode are not affected.     - BS PA backoff adaptation in legacy UEs has to be investigated. Eventually the scheme is not applied in the presence of legacy UEs.   + Potential impact to other WGS     - RAN 1; the whole procedure, i.e, how to trigger the BSs PA backoff adaptation in a given BS and for how long, the coordination with neighbor cells and the measurements to be performed within neighbor cells assessing the eventual impact from PA backoff adaptation is a RAN 1 task.     - RAN 3: coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected.     - RAN 4: finer assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions. |

### Summary of 2nd Round Discussions

#### Proposal #5-1C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-1: Adaptation of transmission power of signals and channels
  + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels
  + Background:
    - In NR, a cell can have only one SSB burst pattern, and all SSBs in a SSB burst have the same Tx power.
    - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique will be applicable to PDSCH. Beside, the technique may be applicable to broadcast channels/signals (e.g., SSB/SI/paging).
    - For 5G NR, the DL transmission power is defined in terms of energy per resource element (EPRE). As specified in TS38.214, a UE assumes that reception occasions of a physical broadcast channel (PBCH), PSS, and SSS are in consecutive symbols, as defined in [4, TS 38.211], and form a SS/PBCH block. And the UE assumes that SSS, PBCH DM-RS, and PBCH data have same EPRE. Practically, based on the output power of TRX(s), the network gNB may configure the DL transmitted EPRE of PBCH data, PBCH DM-RS, and SSS within a cell with the parameter ss-PBCH-BlockPower via ServingCellConfigCommon. Moreover, as specified in TS38.214, the UE may assume that the ratio of PSS EPRE to SSS EPRE in a SS/PBCH block is either 0 dB or 3 dB, meaning that practically if there is zero power offset or 0dB between EPRE of PSS and SSS, the EPRE of PSS could has the same value as ss-PBCH-BlockPower.
    - As specified in TS38.214, for the EPRE of non-zero power (NZP) CSI-RS, it is determined by the network configured parameter powerControlOffsetSS, which is a power offset, on top of the configured value of ss-PBCH-BlockPower. The value range of powerControlOffsetSS can be semi-statically configured of either -3db, 0db, 3db, or 6db according to TS38.331.
    - Practically, the EPRE of PDSCH, PDCCH, and PDCCH DM-RS depends on the number of scheduled PRBs (with the number of allocated resource elements) over the operating BW respectively. And for the case of 256QAM, the power backoff can be further applied for PDSCH transmission to compensate the non-linearity of PA in practice. Moreover, as specified in TS38.214, if the UE has not been provided with dedicated higher layer parameters, the UE may assume that the ratio of PDCCH DM-RS EPRE to SSS EPRE is within -8 dB and 8 dB when the UE monitors PDCCHs for a DCI format 1\_0 with CRC scrambled by SI-RNTI, P-RNTI, or RA-RNTI. And for downlink DM-RS with PDSCH, the UE may assume the ratio of PDSCH EPRE to DM-RS EPRE is according to the number of DM-RS CDM groups without data given by Table 4.1-1 in TS38.214. And when the UE is scheduled with PT-RS port(s) associated with the PDSCH, the ratio of PT-RS EPRE to PDSCH EPRE per layer per RE for each PT-RS port is given by Table 4.1-2 in TS38.214 according to the epre-Ratio if configured by higher layer.
  + Potential specification impacts are:
    - Configuration/re-configuration enhancement of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting (if daynamic transmission power adaptation is applicable to the reference signal)
    - Signalling details to indicate the transmission power or PSD of DL signals and channels, e.g SSB, CSI-RS, PDSCH
    - Enhancements on CSI/RRM measurements, beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
    - Enhancements to CSI measurement and feedback
    - Signalling to inform UE on the transmission power change
    - Signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
    - Need of UE assistant information, e.g.
      * Enhanced CSI report, e.g. report multiple CSI, and each corresponds to a different power offset(hypothetical power offset between CSI-RS and PDSCH) in one CSI report, with corresponding CSI-RS/CSI report configuration enhancement
      * power adjustment indication
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Downlink transmission power reduction may significantly impact the coverage of the cell, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.
  + Potential impact to other WGS
    - Impact on mobility due to dynamic power adaptation of CSI-RS/SSB [RAN2, RAN3]
    - Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be need

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-1: Adaptation of transmission power of signals and channels
  + signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
  + This may include enhancements on UE L1/L3 measurements and L3 filtering behavior due to power adaptation, ~~such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
  + Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell.
  + This may include resource based variation of DL power for various signals & channels
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc, to assist gNB downlink power adaptation
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report

#### Proposal #5-2C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-2: enhancements to assist [gNB digital pre-distortion] and UE post-distortion
  + [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
  + Potential specification impacts are:
    - [To be filled]
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - [To be filled]
  + Potential impact to other WGS
    - [To be filled]
* Technique #D-2a: enhancements to assist [gNB digital pre-distortion] and UE post-distortion
  + [Enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of non-linear kernels, enhanced CSIRS)
    - Introduction of measurements and reporting of DPD information (e.g., report best non-linear kernel out of a list)
    - Introduction of CSI-RS enhancements (e.g., high power low PAPR transmission, rate matching around additional BW than the CSI-RS)
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new CSI-RS. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality
  + Potential impact to other WG
    - Depending on the required change in BS RF requirements from relaxation of pre-distortions, inputs from RAN4 may be needed.
    - RAN4 input on potential UE requirements from support of post-distortion may be needed
* Technique #D-2b : UE post-distortion
  + Background:
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of power amplifier models)
    - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.
    - Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality
  + Potential impact to other WG
    - [to be filled]

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-2a and D-2b: enhancements to assist [gNB digital pre-distortion] and UE post-distortion
  + Enhancements to assist [gNB digital pre-distortion] (DPD-OTA):
    - Justification: digital pre-distortion (DPD) operation requires coupling the Tx output to an Rx feedback chain to capture the non-linearity and estimate it. Beamformed multiple antennas designs, especially in higher bands (i.e., FR2), present new challenges making DPD training at Tx side difficult, as the receiver sees the composite equivalent non-linearity which is the result of all PA’s working in non-linear operating point and summed by the beamforming weighting. DPD needs to capture distortions on the far field beam and not per individual PA in order to account for cross coupling PA NL effects. These effects are not seen in DPD’s Tx coupling feedback
    - Overview: UEs feedback DPD information based on their received signals. The UEs receive training signals in their respective beams, and process the information needed for gNB DPD. The computation schemes of the UE are vast, offering a range of performance and complexity tradeoff. One of them is calculation of the cross correlation of received signal after applying different non-linear kernels to it. The UEs will report the required information over a feedback channel. The gNB will then use the results for post-processing and calculating the DPD coefficients
    - Specification impact:
      * Capability of UEs to support DPD-OTA, activation of DPD process (measurement and reporting of enhanced CSI-RS)
      * Configuration of a set of non-linear kernels by the NW
      * Introduction of measurements and reporting of DPD information (e.g., non-linear kernels) to assist gNB’s DPD
      * Enhancements to CSI-RS, such as transmission of nonlinear CSIRS (with low PAPR and higher transmit power), and possibly allocating a larger BW than the one consisting of the CSI-RS
  + UE digital post-distorsion (DpoD)
    - Overview: Digital Post distortion (DpoD) is non-linear processing on the receiver side. The receiver might implement variety of techniques with various complexity and performance tradeoffs. For example, the UE might implement a post channel equalization non-linear equalization stage that will “invert” the non-linearity introduced by the power amplifier.
    - Specification impact: The DpoD requires knowledge of the power amplifier model that can be obtained by signaling from the gNb to the UE

#### Proposal #5-3C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-3: adaptation of transceiver processing algorithm
  + Tone reservation that decrease PAPR.
    - The UE must be notified of the sub-carriers carrying the TR signal
  + Background:
    - Channel aware Tone Reservation exploits the channel nulls to carry TR tones, providing additional gain over non channel aware tone reservation. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Different transceiver processing algorithms at the gNB should be transparent to the UE
  + Potential specification impacts are:
    - Introducing messaging to inform the UEs of the SCs carrying the TR signal, to be rate matched by the receiver (e.g., in DCI)
    - Introducing enhancements on existing rate-matching patterns (e.g., PRB-symbol bitmaps, CSI-RS)
    - Signaling for providing tone reservation information to UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new rate matching patterns. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality
  + Potential impact to other WGS
    - If the proposal result in any significant changes to RF requirements either at gNB or UE, some inputs from RAN4 may be needed.

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-3: adaptation of transceiver processing algorithm
  + Channel Aware tone Reservation
    - Justification: Tone reservation is a known method that introduces specific tones in a subset of allocated sub-carriers to reduce the PAPR of a transmitted waveform. This PAPR reduction is used to reduce the power consumption of the gNB. Channel aware Tone Reservation exploits the channel nulls to carry those tones and provide additional 1-1.5dB gain over non channel aware TR (and a total of 2.5-3 dB gain over non-TR transmission).
    - Overview: In order to support channel aware tone reservation, where the tones containing the TR signal are changing based on gNB’s decision, the UE receiver must be notified of the sub-carriers carrying the TR signal, and to rate match the data signal around the tones throughput all the symbols. The granularity of the tones is SCs (or several adjacent SCs) and can have several occurrences in frequency.

#### Proposal #5-4C

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #D-4 : PA Input Biasbackoff Adaptation
  + Technique(s) allowing to modify/reduce the input bias backoff in cases of no or low load in the cell and in neighbor cells.
  + Background:
    - PA consumes 60 % to 70 % of the total power consumed at the BS. This PA power consumption is mainly due to high input bias (input voltage, or “backoff”) which is used in order for the PA to operate in the wanted operating region. By adapting the PA “backoff” value by few dB, the PA power consumption is reducing by 50% in the typical PA operating regions. This gain is significantly higher than the gain observed in most of the studied here techniques and therefore not to be ignored.
    - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.
    - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams
    - For the scheme evaluation it is suggested to test the BS PA backoff adaptation of a single cell. E.g. by a reduction of X dB in the PA backoff value, Y dB of unwanted in-band emissions and Z dB of unwanted out-of-band emissions are generated. The impact of the BS PA backoff adaptation of a single cell into N neighbor cells with 1 up to K number of users per cell should be evaluated. The agreed simulation setup should be applied. Once the results of such evaluation are available, and an initial assessment of an eventual impact onto neighbor cells UEs is obtained and the network energy savings are obtained, then RAN 4 has to be contacted for a finer definition of requirements in terms of in-band and out-of-band unwanted emissions.
  + Potential specification impacts are:
    - Eventual UE measurement configurations assessing the impact from BS PA backoff adaptation
    - BS unwanted in-band and out-of-band emissions exchange to neighbor BSs
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - BS PA backoff adaptation should not be applied when SSB/SI is transmitted in the cell and in neighbor cells so as UEs in idle/inactive mode are not affected.
  + BS PA backoff adaptation in legacy UEs has to be investigated. Eventually the scheme is not applied in the presence of legacy UEs.Potential impact to other WGS
    - Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be neededRAN 3: coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected.
    - RAN 4: finer assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions.

Additional description intended to aid evaluations (not part of agreement)

* Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
  + FFS

### [CLOSED] 3rd Round Discussions

Moderator suggests moving all “potential specification impact” and “Additional considerations/aspects (including any impact to legacy UEs, if any)” out of the initial agreement and to the additional information for now. The potential specification impact likely requires further edits and compressing duplicate information.

For the description to be agreed, moderator suggest focusing on the actual technique general description + background + potential impact to other WG

#### Proposal #5-1D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #D-1: Adaptation of transmission power of signals and channels
  + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels
  + Background:
    - In NR, a cell can have only one SSB burst pattern, and all SSBs in a SSB burst have the same Tx power.
    - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique will be applicable to PDSCH. Beside, the technique may be applicable to broadcast channels/signals (e.g., SSB/SI/paging).
    - For 5G NR, the DL transmission power is defined in terms of energy per resource element (EPRE). As specified in TS38.214, a UE assumes that reception occasions of a physical broadcast channel (PBCH), PSS, and SSS are in consecutive symbols, as defined in [4, TS 38.211], and form a SS/PBCH block. And the UE assumes that SSS, PBCH DM-RS, and PBCH data have same EPRE. Practically, based on the output power of TRX(s), the network gNB may configure the DL transmitted EPRE of PBCH data, PBCH DM-RS, and SSS within a cell with the parameter ss-PBCH-BlockPower via ServingCellConfigCommon. Moreover, as specified in TS38.214, the UE may assume that the ratio of PSS EPRE to SSS EPRE in a SS/PBCH block is either 0 dB or 3 dB, meaning that practically if there is zero power offset or 0dB between EPRE of PSS and SSS, the EPRE of PSS could has the same value as ss-PBCH-BlockPower.
    - As specified in TS38.214, for the EPRE of non-zero power (NZP) CSI-RS, it is determined by the network configured parameter powerControlOffsetSS, which is a power offset, on top of the configured value of ss-PBCH-BlockPower. The value range of powerControlOffsetSS can be semi-statically configured of either -3db, 0db, 3db, or 6db according to TS38.331.
    - Practically, the EPRE of PDSCH, PDCCH, and PDCCH DM-RS depends on the number of scheduled PRBs (with the number of allocated resource elements) over the operating BW respectively. And for the case of 256QAM, the power backoff can be further applied for PDSCH transmission to compensate the non-linearity of PA in practice. Moreover, as specified in TS38.214, if the UE has not been provided with dedicated higher layer parameters, the UE may assume that the ratio of PDCCH DM-RS EPRE to SSS EPRE is within -8 dB and 8 dB when the UE monitors PDCCHs for a DCI format 1\_0 with CRC scrambled by SI-RNTI, P-RNTI, or RA-RNTI. And for downlink DM-RS with PDSCH, the UE may assume the ratio of PDSCH EPRE to DM-RS EPRE is according to the number of DM-RS CDM groups without data given by Table 4.1-1 in TS38.214. And when the UE is scheduled with PT-RS port(s) associated with the PDSCH, the ratio of PT-RS EPRE to PDSCH EPRE per layer per RE for each PT-RS port is given by Table 4.1-2 in TS38.214 according to the epre-Ratio if configured by higher layer.
  + Potential impact to other WGS
    - RAN2:
      * Impact on mobility due to dynamic power adaptation of CSI-RS/SSB [RAN2, RAN3]
    - RAN3:
    - RAN4:
      * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be need
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #D-1: Adaptation of transmission power of signals and channels
  + signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
  + This may include enhancements on UE L1/L3 measurements and L3 filtering behavior due to power adaptation, ~~such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
  + Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell.
  + This may include resource based variation of DL power for various signals & channels
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc, to assist gNB downlink power adaptation
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
  + Potential specification impacts are:
    - Configuration/re-configuration enhancement of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting (if daynamic transmission power adaptation is applicable to the reference signal)
    - Signalling details to indicate the transmission power or PSD of DL signals and channels, e.g SSB, CSI-RS, PDSCH
    - Enhancements on CSI/RRM measurements, beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
    - Enhancements to CSI measurement and feedback
    - Signalling to inform UE on the transmission power change
    - Signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
    - Need of UE assistant information, e.g.
      * Enhanced CSI report, e.g. report multiple CSI, and each corresponds to a different power offset(hypothetical power offset between CSI-RS and PDSCH) in one CSI report, with corresponding CSI-RS/CSI report configuration enhancement
      * power adjustment indication
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Downlink transmission power reduction may significantly impact the coverage of the cell, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.

#### Company Comments on Proposal #5-1D

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | Adaptation of transmission power may also have impact on RSs and cell-specific signals, a general description is better at this early time.   * Technique #D-1: Adaptation of transmission power of signals and channels   + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels   + Background:     - In NR, a cell can have only one SSB burst pattern, and all SSBs in a SSB burst have the same Tx power.     - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may ~~will~~ be applicable to PDSCH, CSI-RS, ~~. Beside, the technique may be applicable to~~ broadcast channels/signals (e.g., SSB/SI/paging).   Potential RAN2 impact may be:  RAN2 impact: signaling to trigger the change of power configuration to UEs. |
| CEWiT | The power of CSI-RS and DMRS can also be changed based on channel conditions to conserve energy. In that case the updated power ratios different from semi-statically configured values should be indicated to the UE to reduce the impacts on user performance. Thus we suggest to include the CSI-RS and DM-RS in the applicability of the technique in second bullet of background as follows:   * + Background:     - In NR, a cell can have only one SSB burst pattern, and all SSBs in a SSB burst have the same Tx power.     - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique will be applicable to PDSCH**, CSI-RS, DMRS**. Beside, the technique may be applicable to broadcast channels/signals (e.g., SSB/SI/paging).     - ….     - …. |
| CATT | We are OK with most of the description except the following wording since the Tx power of broadcast and control channel is for coverage. The change of the Tx power of common control and broadcast channel is the change of cell coverage, which should have sufficient justification.   * + - ~~the technique may be applicable to broadcast channels/signals (e.g., SSB/SI/paging).~~ |
| Nokia/NSB | Regarding additional considerations/aspects:  We do not agree with the statement that downlink transmission power reduction may not be applicable to all broadcast channels and signals. In our view, it can be useful also when sending a cell to sleep mode i.e., a gradual reduction of for e.g., the SSB transmission power to make UEs move to another cell, which could avoid potential impact in terms of network access of the UEs.  In general, we think that the power, spatial, frequency, and time domain adaptation has to follow the same framework. It shall be possible to semi-statically configure the different CSI-resources, measurement and reporting configurations specific to each power state and dynamically activate the configuration with a group-common/UE-specific signaling.  We think the potential RAN2 impacts could be:   * RAN2 impact: semi-static configuration and signaling |
| Lenovo | We think downlink transmission power reduction should also be applicable to broadcast channels and signals for some scenarios. When multiple distributed network nodes (e.g. distributed TRPs, repeater) are deployed within a cell, it may be better for some network nodes to transmit broadcast channels/signals with reduced power for energy saving and interference management. |
| InterDigital | We are fine with proposal #5-1D. |
| Ericsson3 | We propose below updates. For background, we do not see the need to repeat what is in the specification. The background should provide any additional details of the proposed techniques instead.   * Technique #D-1: Adaptation of transmission power of signals and channels   + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels   + Background:     - In NR, a cell can have only one SSB burst pattern, and all SSBs in a SSB burst have the same Tx power.     - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, broadcast channels/signals (e.g., SSB/SI/paging), etc.   + Potential impact to other WGS     - RAN2:       * Possible Impact on mobility due to dynamic power adaptation of CSI-RS/SSB [RAN2, RAN3]     - RAN3:     - RAN4:       * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 may needed, for example, on spectral flatness (RE power control dynamic range) and other output power related aspects     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| Intel | We suggest to shorten the background description. Some suggestions are provided as follows:   * + Background:     - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique will be applicable to PDSCH. Beside, the technique may be applicable to broadcast channels/signals (e.g., SSB/SI/paging).     - For 5G NR, the DL transmission power is defined in terms of energy per resource element (EPRE). In NR, a cell can have only one SSB burst pattern, and all SSBs in a SSB burst have the same Tx power. The UE assumes that SSS, PBCH DM-RS, and PBCH data have same EPRE.   As specified in TS38.214, for the EPRE of non-zero power (NZP) CSI-RS, it is determined by network configuration and the EPRE of PDSCH, PDCCH, and PDCCH DM-RS depends on the number of scheduled PRBs (with the number of allocated resource elements) over the operating BW respectively. |
| Huawei, HiSilicon | The following seems ok, as in current FL proposal   * + - RAN2/RAN3:       * Impact on mobility due to dynamic power adaptation of CSI-RS/SSB ~~[RAN2, RAN3]~~     - ~~RAN3:~~     - RAN4:       * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be need |

#### Proposal #5-2D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #D-2 : enhancements to assist gNB digital pre-distortion
  + Enhanced over the air digital pre-distortion at the gNB
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed
      * Depending on the required change in BS RF requirements from relaxation of pre-distortions, inputs from RAN4 may be needed.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #D-2 : enhancements to assist gNB digital pre-distortion
  + Enhancements to assist [gNB digital pre-distortion] (DPD-OTA):
    - Justification: digital pre-distortion (DPD) operation requires coupling the Tx output to an Rx feedback chain to capture the non-linearity and estimate it. Beamformed multiple antennas designs, especially in higher bands (i.e., FR2), present new challenges making DPD training at Tx side difficult, as the receiver sees the composite equivalent non-linearity which is the result of all PA’s working in non-linear operating point and summed by the beamforming weighting. DPD needs to capture distortions on the far field beam and not per individual PA in order to account for cross coupling PA NL effects. These effects are not seen in DPD’s Tx coupling feedback
    - Overview: UEs feedback DPD information based on their received signals. The UEs receive training signals in their respective beams, and process the information needed for gNB DPD. The computation schemes of the UE are vast, offering a range of performance and complexity tradeoff. One of them is calculation of the cross correlation of received signal after applying different non-linear kernels to it. The UEs will report the required information over a feedback channel. The gNB will then use the results for post-processing and calculating the DPD coefficients
    - Specification impact:
      * Capability of UEs to support DPD-OTA, activation of DPD process (measurement and reporting of enhanced CSI-RS)
      * Configuration of a set of non-linear kernels by the NW
      * Introduction of measurements and reporting of DPD information (e.g., non-linear kernels) to assist gNB’s DPD
      * Enhancements to CSI-RS, such as transmission of nonlinear CSIRS (with low PAPR and higher transmit power), and possibly allocating a larger BW than the one consisting of the CSI-RS
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of non-linear kernels, enhanced CSIRS)
    - Introduction of measurements and reporting of DPD information (e.g., report best non-linear kernel out of a list)
    - Introduction of CSI-RS enhancements (e.g., high power low PAPR transmission, rate matching around additional BW than the CSI-RS)
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new CSI-RS. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of power amplifier models)
    - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.
    - Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

#### Company Comments on Proposal #5-2D

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| Company | Comments |
| CATT | We have reservation of this proposal since it is mostly gNB implementation. We don’t agree capturing the proposal at this moment. |
| QCOM5 | @FL: Items in the 2nd round were dropped in the assimilation process:   1. **QCOM2 in 2nd Round Discussions** “For clarity, we suggest **splitting to two techniques (DPD-OTA and DpoD), each with own background, specification impacts and considerations and aspect**   “Description to be expected to be captured into TR (if technique is agreeable to be captured)   * **Technique #D-2a: enhancements to assist [gNB digital pre-distortion] ~~and UE post-distortion~~**   + ~~[Enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.~~   + Background:…..   + <continued descriptions> * **Technique #D-2b : UE post-distortion**   + Background:….   + <continued descriptions>  1. **Proposal #5-2C in Summary of Round 2 Discussions:**   **Added both Technique #D-2a and Technique #D-2b**  “Description to be expected to be captured into TR (if technique is agreeable to be captured)   * Technique #D-2: enhancements to assist [gNB digital pre-distortion] and UE post-distortion   + [enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.   + Background: …. <continued descriptions> * **Technique #D-2a**: **enhancements to assist [gNB digital pre-distortion]** and UE post-distortion   + [Enhanced over the air digital pre-distortion at the gNB and/or] post-distortion at the UE.   + Background: …..   + <continued descriptions> * T**echnique #D-2b**: **UE post-distortion**   + Background: ….   + <continued descriptions>  1. **3rd Round Discussions: technique #D-2b (UE post-distortion) was dropped**     **We kindly ask that technique #D-2b is recaptured as in Summary of 2nd round:**   * Technique #D-2a: enhancements to assist [gNB digital pre-distortion]   + Background:     - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals   + Potential impact to other WG     - RAN2:     - RAN3:     - RAN4:       * ~~UE requirements from support of post-distortion may be needed~~       * Depending on the required change in BS RF requirements from relaxation of pre-distortions, inputs from RAN4 may be needed.     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. * Technique #D-2b : UE post-distortion   + Background:     - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.   + ~~Potential specification impacts are:~~     - ~~High level configuration (e.g., UEs capability, list of power amplifier models)~~     - ~~Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.~~     - ~~Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission~~   + ~~Additional considerations/aspects (including any impact to legacy UEs, if any):~~     - ~~It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality~~   + Potential impact to other WG     - RAN2:     - RAN3:     - RAN4:       * UE requirements from support of post-distortion may be needed |
| Samsung | 1. In the backgournd, it would be fair to point out that the typicl gNBs implement digital pre-distortion in a standard transparent manner. |
| InterDigital | We are fine with proposal #5-2D |

#### Proposal #5-3D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #D-3: adaptation of transceiver processing algorithm
  + Background:
    - Channel aware Tone Reservation exploits the channel nulls to carry TR tones, providing additional gain over non channel aware tone reservation. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Tone reservation that decrease PAPR.
    - The UE must be notified of the sub-carriers carrying the TR signal
  + Different transceiver processing algorithms at the gNB should be transparent to the UE
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
      * If the proposal result in any significant changes to RF requirements either at gNB or UE, some inputs from RAN4 may be needed.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #D-3: adaptation of transceiver processing algorithm
  + Channel Aware tone Reservation
    - Justification: Tone reservation is a known method that introduces specific tones in a subset of allocated sub-carriers to reduce the PAPR of a transmitted waveform. This PAPR reduction is used to reduce the power consumption of the gNB. Channel aware Tone Reservation exploits the channel nulls to carry those tones and provide additional 1-1.5dB gain over non channel aware TR (and a total of 2.5-3 dB gain over non-TR transmission).
    - Overview: In order to support channel aware tone reservation, where the tones containing the TR signal are changing based on gNB’s decision, the UE receiver must be notified of the sub-carriers carrying the TR signal, and to rate match the data signal around the tones throughput all the symbols. The granularity of the tones is SCs (or several adjacent SCs) and can have several occurrences in frequency.
  + Potential specification impacts are:
    - Introducing messaging to inform the UEs of the SCs carrying the TR signal, to be rate matched by the receiver (e.g., in DCI)
    - Introducing enhancements on existing rate-matching patterns (e.g., PRB-symbol bitmaps, CSI-RS)
    - Signaling for providing tone reservation information to UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new rate matching patterns. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

#### Company Comments on Proposal #5-3D

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| Company | Comments |
| CATT | This is gNB implementation without specification impact. We don’t see the need including this in the TR. |
| QCOM5 | @Huawei, “ channel aware” should be deleted. Whether TR is channel aware or not is up to gNB implementation.]  We disagree. Channel aware tone reservation is not just up to gNB implementation. Quoting **overview QCOM2**: “In order to support channel aware tone reservation, where the tones containing the TR signal are changing based on gNB’s decision, the UE receiver must be notified of the sub-carriers carrying the TR signal, and to rate match the data signal around the tones throughput all the symbols. This is also captured in the suggested description to the TR “The UE must be notified of the sub-carriers carrying the TR signal”  In “non channel aware” tone reservation, the TR signal can be inserted in fixed allocations without notifying the UE. Referring to **Justification QCOM2:** “Channel aware Tone Reservation exploits the channel nulls to carry those tones and provide additional 1-1.5dB gain over non channel aware TR (and a total of 2.5-3 dB gain over non-TR transmission).”  **We object to removal of “channel Aware” form Tone Reservation and suggest the following modifications to also capture the added text as relevant only to it as provided in QCOM2**   * Technique #D-3: adaptation of transceiver processing algorithm   + Background:     - Channel aware Tone Reservation exploits the channel nulls to carry TR tones, providing additional gain over non channel aware tone reservation. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes     - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.   + Channel Aware Tone reservation that decrease**s** PAPR.     - The UE must be notified of the sub-carriers carrying the TR signal and therefor is not be transparent to the UE     - ~~Potential specification impacts are either or both of:~~       * ~~Introducing messaging to inform the UEs of the SCs carrying the TR signal, to be rate matched by the receiver (e.g., in DCI)~~       * ~~Introducing enhancements on existing rate-matching patterns (e.g., PRB-symbol bitmaps, CSI-RS)~~     - ~~Additional considerations/aspects (including any impact to legacy UEs, if any):~~       * ~~Legacy UEs are not aware of the new rate matching patterns. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality~~   + Different transceiver processing algorithms at the gNB should be transparent to the UE   + Potential impact to other WGS     - RAN2:     - RAN3:     - RAN4:       * If the proposal result in any significant changes to RF requirements either at gNB or UE, some inputs from RAN4 may be needed.     - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI. |
| Samsung | 1. RAN4 impact should not be necessarily ‘significant’:   -----   * + Potential impact to other WGS     - RAN2:     - RAN3:     - RAN4: ~~If the proposal result in any significant changes to~~ RF requirements either at gNB or UE~~, some inputs from RAN4 may be needed.~~   ------- |
| InterDigital | We are fine with Proposal #5-3D |
| Intel | UE signaling aspects can be left to specification impact aspect. Suggest the following:  Tone reservation that decrease PAPR.  ~~The UE must be notified of the sub-carriers carrying the TR signal~~ |

#### Proposal #5-4D

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #D-4 : PA Input Biasbackoff Adaptation
  + Technique(s) allowing to modify/reduce the input bias backoff in cases of no or low load in the cell and in neighbor cells.
  + Background:
    - PA consumes 60 % to 70 % of the total power consumed at the BS. This PA power consumption is mainly due to high input bias (input voltage, or “backoff”) which is used in order for the PA to operate in the wanted operating region. By adapting the PA “backoff” value by few dB, the PA power consumption is reducing by 50% in the typical PA operating regions. This gain is significantly higher than the gain observed in most of the studied here techniques and therefore not to be ignored.
    - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.
    - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams
    - For the scheme evaluation it is suggested to test the BS PA backoff adaptation of a single cell. E.g. by a reduction of X dB in the PA backoff value, Y dB of unwanted in-band emissions and Z dB of unwanted out-of-band emissions are generated. The impact of the BS PA backoff adaptation of a single cell into N neighbor cells with 1 up to K number of users per cell should be evaluated. The agreed simulation setup should be applied. Once the results of such evaluation are available, and an initial assessment of an eventual impact onto neighbor cells UEs is obtained and the network energy savings are obtained, then RAN 4 has to be contacted for a finer definition of requirements in terms of in-band and out-of-band unwanted emissions.
    - RAN 3:.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
      * coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected
    - RAN4:
      * Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be needed
      * Finer assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique #D-4: PA Input Power Bias (“input backoff”) Adaptation
  + Potential specification impacts are:
    - Eventual UE measurement configurations assessing the impact from BS PA backoff adaptation
    - BS unwanted in-band and out-of-band emissions exchange to neighbor BSs
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - BS PA backoff adaptation should not be applied when SSB/SI is transmitted in the cell and in neighbor cells so as UEs in idle/inactive mode are not affected.
    - BS PA backoff adaptation in legacy UEs has to be investigated. Eventually the scheme is not applied in the presence of legacy UEs.

#### Company Comments on Proposal #5-4D

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| --- | --- |
| Company | Comments |
| CATT | This is gNB implementation without specification impact. We don’t see the need including this in the TR. |
| QCOM5 | The name of the technique should change to  **Technique #D-4: PA Backoff Adaptation**  Indeed this method can be implemented at the gNB without any signaling to UEs or without any coordination with other BSs. However, there are more opportunities for network energy savings, when the BS PA backoff adaptation occurs in the typical regions of BS PA operation. |
| Samsung | 1. Regarding the entire first bullet in the background, RAN1 has not yet observed such gains and comparison with other techniques. uggest to remove the first bullet. |
| Intel | Explanation on how to perform evaluation may not be needed for the background.  Suggest removing the following:   * + - ~~For the scheme evaluation it is suggested to test the BS PA backoff adaptation of a single cell. E.g. by a reduction of X dB in the PA backoff value, Y dB of unwanted in-band emissions and Z dB of unwanted out-of-band emissions are generated. The impact of the BS PA backoff adaptation of a single cell into N neighbor cells with 1 up to K number of users per cell should be evaluated. The agreed simulation setup should be applied. Once the results of such evaluation are available, and an initial assessment of an eventual impact onto neighbor cells UEs is obtained and the network energy savings are obtained, then RAN 4 has to be contacted for a finer definition of requirements in terms of in-band and out-of-band unwanted emissions.~~ |

#### Proposal #5-5

The following is a description of a potential energy saving technique being discussed in RAN1. The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

* Technique #D-5: UE post-distortion
  + Background:
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

* Technique # D-5: UE post-distortion
  + UE digital post-distorsion (DpoD)
    - Overview: Digital Post distortion (DPoD) is non-linear processing on the receiver side. The receiver might implement variety of techniques with various complexity and performance tradeoffs. For example, the UE might implement a post channel equalization non-linear equalization stage that will “invert” the non-linearity introduced by the power amplifier.
    - Specification impact: The DPoD requires knowledge of the power amplifier model that can be obtained by signaling from the gNb to the UE
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of power amplifier models)
    - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.
    - Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

#### Company Comments on Proposal #5-5

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| Company | Comments |
| CATT | This is gNB implementation without specification impact. We don’t see the need including this in the TR. |
| InterDigital | We are fine with proposal #5-5 |

### [ACTIVE] 4th Round Discussions

#### Proposal #5-1E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #D-1: Adaptation of transmission power of signals and channels
  + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels
  + Background:
    - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, CSI-RS,DMRS, broadcast channels/signals (e.g., SSB/SI/paging).
  + Potential impact to other WGS
    - RAN2:
      * Possible impact on mobility due to dynamic power adaptation of CSI-RS/SSB
      * Configuration and signaling of indication of power related parameters to the UEs
    - RAN3:
      * Impact on mobility due to dynamic power adaptation of CSI-RS/SSB
    - RAN4:
      * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 may be needed, for example, spectral flatness (RE power control dynamic range) and other output power related aspects
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #5-1F

* Technique #D-1: Adaptation of transmission power of signals and channels
  + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels
  + Background:
    - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, CSI-RS, DMRS, broadcast channels/signals (e.g., SSB/SI/paging).
  + Potential impact to other WGS
    - RAN2:
      * Possible impact on mobility due to dynamic power adaptation of CSI-RS/SSB
      * Configuration and signaling of indication of power related parameters to the UEs
    - RAN3:
    - RAN4:
      * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 may be needed, for example, spectral flatness (RE power control dynamic range) and other output power related aspects

#### Proposal #5-1G

* Technique #D-1: Adaptation of transmission power of signals and channels
  + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels
  + Background:
    - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, CSI-RS, DMRS, broadcast channels/signals (e.g., SSB/SI/paging).
    - The power offset configurations for PDSCH, CSI-RS and DMRS are BWP-specific, and BWP adaptation framework can be utilized for the adaptation of the settings.
  + Potential impact to other WGS
    - RAN2:
      * Possible impact on mobility due to dynamic power adaptation of CSI-RS/SSB
      * Configuration and signaling of indication of power related parameters to the UEs
    - RAN3:
    - RAN4:
      * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 may be needed, for example, spectral flatness (RE power control dynamic range) and other output power related aspects

#### Company Comments on Proposal #5-1E/F/G

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| --- | --- |
| Company | Comments |
| LG Electronics | We are OK with Proposal #5-1E. |
| DOCOMO | We are fine with FL’s summary. |
| ZTE, Sanechips | The following bullet has minimal impact on RAN3, it can be removed.   * + Potential impact to other WGS     - RAN3:       * ~~Impact on mobility due to dynamic power adaptation of CSI-RS/SSB~~ |
| CEWiT | We are fine with the proposal |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Updated proposal to #5-1F based on comments. |
| Apple | OK |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
| Mediatek | * On **Technique #D-1: Adaptation of transmission power of signals and channels**, the power offset configurations for PDSCH, CSI-RS and DMRS are BWP specific. For dynamic adaptation, BWP adaptation framework can be utilized based on current specification. The following update is suggested accordingly:  |  | | --- | | * + Background:     - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, CSI-RS, DMRS, broadcast channels/signals (e.g., SSB/SI/paging).     - The power offset configurations for PDSCH, CSI-RS and DMRS are BWP-specific, and BWP adaptation framework can be utilized for the adaptation of the settings. | |
| Moderator | Updated in #5-1G |
| LG Electronics | From our understanding, DMRS power offset is not configured. Also, similar to Proposal #2-2H, we suggest to add some more wording, as follows.   * + Background:     - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, CSI-RS, DMRS, broadcast channels/signals (e.g., SSB/SI/paging).     - The power offset configurations for PDSCH and CSI-RS are BWP-specific, and BWP adaptation framework can be utilized for the adaptation of the settings for a UE capable of multiple BWPs and dynamic BWP switching. |

#### Proposal #5-2E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #D-2: enhancements to assist gNB digital pre-distortion
  + Enhanced over the air digital pre-distortion at the gNB
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals.
    - Note that some companies pointed out gNB may be able to implement digital pre-distortion in a standard transparent manner.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed
      * Depending on the required change in BS RF requirements from relaxation of pre-distortions, inputs from RAN4 may be needed.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #5-2F

* Technique #D-2: enhancements to assist gNB digital pre-distortion
  + Enhanced over the air digital pre-distortion at the gNB
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals.
    - Note that some companies pointed out gNB may be able to implement digital pre-distortion in a standard transparent manner.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed
      * Depending on the required change in BS RF requirements from relaxation of pre-distortions, inputs from RAN4 may be needed.

#### Proposal #5-2G – GTW Check Needed

* Technique #D-2: enhancements to assist gNB digital pre-distortion
  + Enhanced over the air digital pre-distortion at the gNB
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals.
    - Note that some companies pointed out gNB may be able to implement digital pre-distortion in a standard transparent manner.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * Investigation on UE requirements from support of post-distortion
      * Investigation on the required change in BS RF requirements from relaxation of pre-distortions
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

#### Company Comments on Proposal #5-2E/F/G

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| Company | Comments |
| Moderator | @Qualcomm:  Technique D-2b was moved to Technique D-5 (just renumeration). Please check if that is ok |
| LG Electronics | As other companies commented previously, this technique should be studied in RAN4 first. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Moderator assumes we can still have the description agreed so that RAN4 can look into the proposal (if RAN4 determines to do so). The other purpose for the description is to aid evaluations as well. Let’s focus on making the description clear. |
| Apple | We prefer not to refine the description in RAN1 as it is not considered as RAN1 domain. We are particularly concerned on the RAN4 impact part, because it says “inputs from RAN4 may be needed”, while our understanding is that the main investigation should be done in RAN4. |
| Moderator | Updated RAN4 impact to address LGE and Apple concerns. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
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#### Proposal #5-3E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #D-3: adaptation of transceiver processing algorithm
  + Background:
    - Channel aware Tone Reservation exploits the channel nulls to carry TR tones, providing additional gain over non channel aware tone reservation. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Channel aware tone reservation that decrease PAPR.
  + Different transceiver processing algorithms at the gNB should be transparent to the UE
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
      * RF requirements either at gNB or UE.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #5-3F

* Technique #D-3: adaptation of transceiver processing algorithm
  + Background:
    - Tone Reservation exploits the channel nulls to carry TR tones, potentially taking into account channel conditions and characteristics. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes.
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Tone reservation that decreases PAPR, potentially taking into account channel conditions and characteristics
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
      * RF requirements either at gNB or UE.

#### Proposal #5-3G

* Technique #D-3: adaptation of transceiver processing algorithm
  + Background:
    - Tone Reservation exploits the channel nulls to carry TR tones, potentially taking into account channel conditions and characteristics. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes.
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
      * RF requirements either at gNB or UE.

#### Company Comments on Proposal #5-3E/F

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| --- | --- |
| Company | Comments |
| LG Electronics | As other companies commented previously, this technique should be studied in RAN4 first. |
| Samsung | 1) For clarification, what does the following bullet mean?: *“Different transceiver processing algorithms at the gNB should be transparent to the UE”.* We are OK with the ‘transparent’ part. However, the background says “The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes” which is NOT transparent to the UE.  2) If RAN1 is to analyize tone reservation technique, ‘channel awareness’ can be removed for now. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  There is quite of bit of discussion on whether or not to keep “channel awareness” working.  Moderator has suggested some changes that could be more neutral.  Updated the proposal to #5-3F. |
| Apple | Should the 2nd bullet be moved to the 1st bullet to keep the same structure as the other techniques?  Is the intention now that we should study this in RAN1? We think we should first clarify whether we plan to take the investigation for some of these techniques in RAN1 or not, before discussing these techniques again and again. |
| Moderator | @Apple,  It will be up to the companies to provide contributions with analysis and/or assement. Not sure if we want to have a discussion on what the procedures should be for RAN1 to conduct study. RAN1 is primarily contribution driven, so I assume companies will provide some information to the table.  As mentioned RAN1 is not agreeing to the proposal for standardization now. If the description helps companies to think and bring insightful information in the next meeting, then moderator assumes there is some value in agreeing to the description. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
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#### Proposal #5-4E

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #D-4: PA backoff adaptation
  + Technique(s) allowing to modify/reduce the input bias backoff in cases of no or low load in the cell and in neighbor cells.
  + Background:
    - PA consumes 60 % to 70 % of the total power consumed at the BS. This PA power consumption is mainly due to high input bias (input voltage, or “backoff”) which is used in order for the PA to operate in the wanted operating region. By adapting the PA “backoff” value by few dB, the PA power consumption is reducing by 50% in the typical PA operating regions. This gain is significantly higher than the gain observed in most of the studied here techniques and therefore not to be ignored.
    - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.
    - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams
  + Potential impact to other WG
    - RAN2:
    - RAN3:
      * coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected
    - RAN4:
      * Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be needed
      * Finer assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions.
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #5-4F

* Technique #D-4: PA backoff adaptation
  + Technique(s) allowing to modify/reduce the input bias backoff in cases of no or low load in the cell and in neighbor cells.
  + Background:
    - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.
    - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams
  + Potential impact to other WG
    - RAN2:
    - RAN3:
      * coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected
    - RAN4:
      * Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects may be needed
      * Finer assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions.

#### Proposal #5-4G – GTW Check Needed

* Technique #D-4: PA backoff adaptation
  + Technique(s) allowing to modify/reduce the input bias backoff in cases of no or low load in the cell and in neighbor cells.
  + Background:
    - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.
    - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams
  + Potential impact to other WG
    - RAN2:
    - RAN3:
      * coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected
    - RAN4:
      * Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects
      * Assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions.
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

#### Company Comments on Proposal #5-4E/F/G

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| --- | --- |
| Company | Comments |
| LG Electronics | As other companies commented previously, this technique should be studied in RAN4 first. |
| Samsung | Repeating ourselves, on the statement of the entire first bullet in the background, RAN1 has not yet observed such gains and comparison with other techniques. Therefore, we sugget to remove the first bullet in the background.  ----   * + Background:     - ~~PA consumes 60 % to 70 % of the total power consumed at the BS. This PA power consumption is mainly due to high input bias (input voltage, or “backoff”) which is used in order for the PA to operate in the wanted operating region. By adapting the PA “backoff” value by few dB, the PA power consumption is reducing by 50% in the typical PA operating regions. This gain is significantly higher than the gain observed in most of the studied here techniques and therefore not to be ignored.~~   ---- |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Moderator assumes we can still have the description agreed so that RAN4 can look into the proposal (if RAN4 determines to do so). The other purpose for the description is to aid evaluations as well. Let’s focus on making the description clear.  Updated to Proposal #5-4F. |
| Apple | We prefer not to refine the description in RAN1 as it is not considered as RAN1 domain. We are particularly concerned on the RAN4 impact part, because it says “some input from RAN4” “may be needed”, while our understanding is that the main investigation should be done in RAN4.  In any case, we should clarify whether we are going to investigate these further in RAN1 before spending more time on it. |
| Moderator | Updated to address concerns from LGE and Apple. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
|  |  |

#### Proposal #5-5A

In the study of network energy savings for NR, RAN1 has identified some potential techniques. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs, and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

* Technique #D-5: UE post-distortion
  + Background:
    - In UE post-distortion, the gNB assist the UE in reducing nonlinear impairments introduced by its PA (e.g., non-linear equalization stage that will “invert” the non-linearity), by sending RS signal at low periodically or some signaling to the UE.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed
    - Note: the potential impact to other WG is not an exhaustive list nor represent definitive list of impacts to WGs. It provides a list of potential impact that RAN1 has identified so far and is subject to further changes as RAN1 progress work for the SI.

#### Proposal #5-5B

* Technique #D-5: UE post-distortion
  + UE performing received signal post-distortion processing (e.g. non-linear equalization stage that will “invert” the non-linearity) to combat non-linear impairments from the transmitter.
  + Transmission of reference signals or information to aid the UE to perform post-distortion processing.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed

#### Proposal #5-5C – GTW Check Needed

* Technique #D-5: UE post-distortion
  + UE performing received signal post-distortion processing (e.g. non-linear equalization stage that will “invert” the non-linearity) to combat non-linear impairments from the transmitter.
  + Transmission of reference signals or information to aid the UE to perform post-distortion processing.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

#### Company Comments on Proposal #5-5A/B/C

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| --- | --- |
| Company | Comments |
| LG Electronics | As other companies commented previously, this technique should be studied in RAN4 first. |
| Moderator | Moderator suggested Proposal #1-2 as the boiler template for agreeing to the technique descriptions. Therefore, removed any text related to this.  Moderator assumes we can still have the description agreed so that RAN4 can look into the proposal (if RAN4 determines to do so). The other purpose for the description is to aid evaluations as well. Let’s focus on making the description clear.  As noted, this proposal is missing a general description. Moderator tried to add it based on the background information. Moderator asks the proponents to double check.  Updated to Proposal #5-5B. |
| Apple | We prefer not to refine the description in RAN1 as it is not considered as RAN1 domain.  In any case, we should clarify whether we are going to investigate these further in RAN1 before spending more time on it. |
| Moderator | If additional comments add them here & also announce that you added feedback on this issue over email. |
|  |  |

#### Other Aspects (not part of agreement)

The following is additional description of a potential energy saving technique #A-1 intended to help companies perform evaluations and further understand the various of the technique. The following is not suggested to be part of the agreement, but should be understood as basis for further discussion in RAN1.

##### Technique #D-1: Adaptation of transmission power of signals and channels

* + signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
  + This may include enhancements on UE L1/L3 measurements and L3 filtering behavior due to power adaptation, ~~such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
  + Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell.
  + This may include resource based variation of DL power for various signals & channels
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc, to assist gNB downlink power adaptation
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
  + Potential specification impacts are:
    - Configuration/re-configuration enhancement of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting (if daynamic transmission power adaptation is applicable to the reference signal)
    - Signalling details to indicate the transmission power or PSD of DL signals and channels, e.g SSB, CSI-RS, PDSCH
    - Enhancements on CSI/RRM measurements, beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
    - Enhancements to CSI measurement and feedback
    - Signalling to inform UE on the transmission power change
    - Signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
    - Need of UE assistant information, e.g.
      * Enhanced CSI report, e.g. report multiple CSI, and each corresponds to a different power offset(hypothetical power offset between CSI-RS and PDSCH) in one CSI report, with corresponding CSI-RS/CSI report configuration enhancement
      * power adjustment indication
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Downlink transmission power reduction may significantly impact the coverage of the cell, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.

##### Technique #D-2: enhancements to assist gNB digital pre-distortion

* + Enhancements to assist [gNB digital pre-distortion] (DPD-OTA):
    - Justification: digital pre-distortion (DPD) operation requires coupling the Tx output to an Rx feedback chain to capture the non-linearity and estimate it. Beamformed multiple antennas designs, especially in higher bands (i.e., FR2), present new challenges making DPD training at Tx side difficult, as the receiver sees the composite equivalent non-linearity which is the result of all PA’s working in non-linear operating point and summed by the beamforming weighting. DPD needs to capture distortions on the far field beam and not per individual PA in order to account for cross coupling PA NL effects. These effects are not seen in DPD’s Tx coupling feedback
    - Overview: UEs feedback DPD information based on their received signals. The UEs receive training signals in their respective beams, and process the information needed for gNB DPD. The computation schemes of the UE are vast, offering a range of performance and complexity tradeoff. One of them is calculation of the cross correlation of received signal after applying different non-linear kernels to it. The UEs will report the required information over a feedback channel. The gNB will then use the results for post-processing and calculating the DPD coefficients
    - Specification impact:
      * Capability of UEs to support DPD-OTA, activation of DPD process (measurement and reporting of enhanced CSI-RS)
      * Configuration of a set of non-linear kernels by the NW
      * Introduction of measurements and reporting of DPD information (e.g., non-linear kernels) to assist gNB’s DPD
      * Enhancements to CSI-RS, such as transmission of nonlinear CSIRS (with low PAPR and higher transmit power), and possibly allocating a larger BW than the one consisting of the CSI-RS
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of non-linear kernels, enhanced CSIRS)
    - Introduction of measurements and reporting of DPD information (e.g., report best non-linear kernel out of a list)
    - Introduction of CSI-RS enhancements (e.g., high power low PAPR transmission, rate matching around additional BW than the CSI-RS)
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new CSI-RS. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of power amplifier models)
    - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.
    - Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

##### Technique #D-3: adaptation of transceiver processing algorithm

* + Channel Aware tone Reservation
    - Justification: Tone reservation is a known method that introduces specific tones in a subset of allocated sub-carriers to reduce the PAPR of a transmitted waveform. This PAPR reduction is used to reduce the power consumption of the gNB. Channel aware Tone Reservation exploits the channel nulls to carry those tones and provide additional 1-1.5dB gain over non channel aware TR (and a total of 2.5-3 dB gain over non-TR transmission).
    - Overview: In order to support channel aware tone reservation, where the tones containing the TR signal are changing based on gNB’s decision, the UE receiver must be notified of the sub-carriers carrying the TR signal, and to rate match the data signal around the tones throughput all the symbols. The granularity of the tones is SCs (or several adjacent SCs) and can have several occurrences in frequency.
  + Potential specification impacts are:
    - Introducing messaging to inform the UEs of the SCs carrying the TR signal, to be rate matched by the receiver (e.g., in DCI)
    - Introducing enhancements on existing rate-matching patterns (e.g., PRB-symbol bitmaps, CSI-RS)
    - Signaling for providing tone reservation information to UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new rate matching patterns. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

##### Technique #D-4: PA Input Power Bias ("input backoff”) Adaptation

* + Potential specification impacts are:
    - Eventual UE measurement configurations assessing the impact from BS PA backoff adaptation
    - BS unwanted in-band and out-of-band emissions exchange to neighbor BSs
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - BS PA backoff adaptation should not be applied when SSB/SI is transmitted in the cell and in neighbor cells so as UEs in idle/inactive mode are not affected.
    - BS PA backoff adaptation in legacy UEs has to be investigated. Eventually the scheme is not applied in the presence of legacy UEs.

##### Technique #D-5: UE post-distortion

* + UE digital post-distorsion (DPoD)
    - Overview: Digital Post distortion (DPoD) is non-linear processing on the receiver side. The receiver might implement variety of techniques with various complexity and performance tradeoffs. For example, the UE might implement a post channel equalization non-linear equalization stage that will “invert” the non-linearity introduced by the power amplifier.
    - Specification impact: The DPoD requires knowledge of the power amplifier model that can be obtained by signaling from the gNb to the UE
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of power amplifier models)
    - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.
    - Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

#### Company Comments on other aspects

|  |  |
| --- | --- |
| Company | Comments |
| - | - |

### == Summary of 4th Round Discussions ==

The proposals are getting more stable. Here are the updates proposals for power domain techniques. Moderator suggests agreeing the following proposal.

#### Proposal #5-1G

* Technique #D-1: Adaptation of transmission power of signals and channels
  + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels
  + Background:
    - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, CSI-RS, DMRS, broadcast channels/signals (e.g., SSB/SI/paging).
    - The power offset configurations for PDSCH, CSI-RS and DMRS are BWP-specific, and BWP adaptation framework can be utilized for the adaptation of the settings.
  + Potential impact to other WGS
    - RAN2:
      * Possible impact on mobility due to dynamic power adaptation of CSI-RS/SSB
      * Configuration and signaling of indication of power related parameters to the UEs
    - RAN3:
    - RAN4:
      * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 may be needed, for example, spectral flatness (RE power control dynamic range) and other output power related aspects

#### Proposal #5-2G – GTW Check Needed

* Technique #D-2: enhancements to assist gNB digital pre-distortion
  + Enhanced over the air digital pre-distortion at the gNB
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals.
    - Note that some companies pointed out gNB may be able to implement digital pre-distortion in a standard transparent manner.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * Investigation on UE requirements from support of post-distortion
      * Investigation on the required change in BS RF requirements from relaxation of pre-distortions
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

#### Proposal #5-3G

* Technique #D-3: adaptation of transceiver processing algorithm
  + Tone reservation that decreases PAPR, potentially taking into account channel conditions and characteristics
  + Background:
    - Tone Reservation exploits the channel nulls to carry TR tones, potentially taking into account channel conditions and characteristics. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes.
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
      * RF requirements either at gNB or UE.

#### Proposal #5-4G – GTW Check Needed

* Technique #D-4: PA backoff adaptation
  + Technique(s) allowing to modify/reduce the input bias backoff in cases of no or low load in the cell and in neighbor cells.
  + Background:
    - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.
    - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams
  + Potential impact to other WG
    - RAN2:
    - RAN3:
      * coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected
    - RAN4:
      * Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects
      * Assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions.
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

#### Proposal #5-5C – GTW Check Needed

* Technique #D-5: UE post-distortion
  + UE performing received signal post-distortion processing (e.g. non-linear equalization stage that will “invert” the non-linearity) to combat non-linear impairments from the transmitter.
  + Transmission of reference signals or information to aid the UE to perform post-distortion processing.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

## 2.6 Other Energy Saving Aspects/Techniques

* [12] ZTE, Sanechips
  + UE assistance information can help network to better acquire UE’s requirements, so that the energy saving techniques can be adjusted more accurately to reduce the impact on user experience and assist network energy saving.
  + The UE assistance information can be considered for network energy saving.
* [17] Mediatek
  + Proposal 13: Efficient UE-group/cell-wise signaling and adaptation mechanism should be developed for useful NW energy saving techniques; otherwise the signaling overhead and power consumption will reduce the energy saving benefits.
  + Proposal 14: For maximum UE support, extend Rel-15 BWP adaptation framework as the UE-group/cell-wise signaling and adaptation mechanism for NW energy saving.
* [18] Apple
  + Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving
    - Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into a dormant power state or not.
    - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques
    - UE assistance information including traffic relation information, such as pattern, volume etc.
    - UE report of certain measurement, e.g., based on discovery reference signal.
      * [Comment] This can be merged into A-1.
    - UE assistance data for gNB to assess whether it can go into a sleeping state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.
* [23] Samsung
  + Proposal 28: Support PUCCH transmission with negative SR.
  + Proposal 29: Support UE assistance information for SSB request during network energy saving state.
  + Observation 5: UE assistance signaling for indicating an SR/CG PUSCH transmission is beneficial for network power consumption.
  + Proposal 30: Support UE assistance information for indicating an SR/CG PUSCH transmission during network energy saving state.
  + Proposal 31: Consider the following changes to the TP for TR
    - Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving
      * Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into a dormant power state or not.
      * Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques
      * UE assistance information including traffic relation information, such as pattern, volume etc.
      * UE report of certain measurement, e.g., based on discovery reference signal.
      * UE assistance data for gNB to assess whether it can go into a sleeping state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.
      * UE request of SSB configuration
      * SR/CG PUSCH transmission indication

### [CLOSED] 1st Round Discussions

Companies should start thinking about what potential techniques to capture and what information would be captured together with the techniques. Moderator suggests refining the technique description further based on what was discussed in RAN1 #110. Discussion should include any suggestions to splitting or merging the techniques listed.

Please comment further on the following proposals, including comments to address notes from the moderator below.

#### Proposal #6-1

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving (1)
  + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into a dormant power state or not.
    - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques
  + UE assistance information including traffic relation information, such as pattern, volume etc.
  + UE report of certain measurement, e.g., based on discovery reference signal.
  + UE assistance data for gNB to assess whether it can go into a sleeping state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.

Moderator notes:

* Note (1)
  + This is generally true however as it is assisted information, instead of techniques standalone, it may be preferred to be included/reflected into each technique, using a separate sub-section.

#### Company Comments on Proposal #6-1

|  |  |
| --- | --- |
| Company | Comments |
| Xiaomi | Proposal #6-1 seems miss out the part about CG-PUSCH. And we add it as follows:   * Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving (1)   + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into a dormant power state or not.     - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques   + UE assistance information including CG-PUSCH transmission information, traffic relation information, such as pattern, volume etc.   + UE report of certain measurement, e.g., based on discovery reference signal.   + UE assistance data for gNB to assess whether it can go into a sleeping state, e.g. polling number of idle UEs, polling UEs beyond certain coverage. |
| Samsung | We want to add the following two bullets as examples:   * UE request of SSB configuration * SR/CG PUSCH transmission indication   We suggest the following update highlight yellow. Proposal #6-1  * The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR. * Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving (1)   + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into a dormant power state or not.     - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques   + UE assistance information including traffic relation information, such as pattern, volume etc.   + UE report of certain measurement, e.g., based on discovery reference signal.   + UE assistance data for gNB to assess whether it can go into a sleeping state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.   + UE request of SSB configuration   + SR/CG PUSCH transmission indication |
| Intel | We suggest using a unified terminology for power saving state at the gNB. For example, following can be considered   * + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into an ~~dormant power~~energy saving state or not.   + UE assistance data for gNB to assess whether it can go into an ~~sleeping~~ energy saving state, e.g. polling number of idle UEs, polling UEs beyond certain coverage. |
| Apple | We agree with the feature lead that it is better to merge UE assistance info into each technique, unless it can work as a stand-alone option. |
| CATT | We could discuss any text description once the evaluation results with network energy saving gain observed |
|  |  |

### Summary of 1st Round Discussions

Based on feedback received moderator has updated the proposals as follows. Moderator suggest using the updated proposal for further discussions.

Notation of change marks above:

* Red Underline or ~~Stikethrough~~ Text: Updated text based on comments.
* Blue Underline Text: Updated text based on comments. However, moderator thinks further clarification is needed
* Green Text: Unchanged text. However, based on comments, moderator thinks further clarification is needed.

Proposal #6-1A

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving
  + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into an energy saving state ~~a dormant power state~~ or not.
    - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques
  + UE assistance information including CG-PUSCH transmission information, traffic relation information, such as pattern, volume etc.
  + UE report of certain measurement, e.g., based on discovery reference signal.
  + UE assistance data for gNB to assess whether it can go into an energy saving state ~~a sleeping state~~, e.g. polling number of idle UEs, polling UEs beyond certain coverage.
  + UE request of SSB configuration
  + SR/CG PUSCH transmission indication

Proposal #6-1A (clean)

* The following descriptions are basis for further discussion and evaluations. If the text agreeable after further updates, discuss on whether to capture into the TR.
* Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving
  + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into an energy saving state or not.
    - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques
  + UE assistance information including CG-PUSCH transmission information, traffic relation information, such as pattern, volume etc.
  + UE report of certain measurement, e.g., based on discovery reference signal.
  + UE assistance data for gNB to assess whether it can go into an energy saving state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.
  + UE request of SSB configuration
  + SR/CG PUSCH transmission indication

### [CLOSED] 2nd Round Discussions

Based on discussion from GTW, we should split the discussion into two components. First aspect is regarding high level descriptions of the potential techniques, their potential specification impact, any impact to legacy UEs. The second aspect is providing even further details targeting providing information for evaluations.

#### Proposal #6-1A

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving
  + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into an energy saving state or not.
    - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques
  + UE assistance information including CG-PUSCH transmission information, traffic relation information, such as pattern, volume etc.
  + UE report of certain measurement, e.g., based on discovery reference signal.
  + UE assistance data for gNB to assess whether it can go into an energy saving state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.
  + UE request of SSB configuration
  + SR/CG PUSCH transmission indication
  + Potential impact to other WGS
    - [To be filled]

#### Company Comments on Proposal #6-1A

Moderator asks companies to also provide view and details, including the following aspects:

* Which details should be included in the main proposal description (not the additional information for evaluation)
* Most likely for UE assistance information, separate information of background/spec impact/additional consideration is needed. Therefore, for each of the potential UE assistance information any ‘background’, ‘potential specification impact’ and ‘additional consideration’ information.

|  |  |
| --- | --- |
| Company | Comments |
| LG Electronics | Those bullets are unclear so proponents should make those much clearer. For example, CG-PUSCH is duplicated, the definition of discovery reference signal needs to be defined, polling mechanism needs to be clarified, and SSB configuration needs to be clarified.   * + UE assistance information including CG-PUSCH transmission information, traffic relation information, such as pattern, volume etc.   + UE report of certain measurement, e.g., based on discovery reference signal.   + UE assistance data for gNB to assess whether it can go into an energy saving state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.   + UE request of SSB configuration   + SR/CG PUSCH transmission indication |
| Moderator | I’ve added a sub-bullet on impact to other WGs. I ask companies to also provide information on this, as it can be important for the overall work. |
| CATT | The evaluation results with significant power saving gain should be shown first before we capture any proposal in TR. |
| Apple | We agree it is better to have this included in the corresponding techniques, instead of being separately listed. |
| Samsung | Fine with the proposal. |

### Summary of 2nd Round Discussions

It was suggested to merge the potential UE assistance information along with the different energy saving techniques. Moderator suggest to check with companies on removing Proposal #6-1B and merging the contents to applicable energy saving techniques in other sections.

Companies requested further elaboration of the listed UE assistance information in BLUE as the description is too brief to understand.

#### Proposal #6-1B – Discuss in GTW

Description to be expected to be captured into TR (if technique is agreeable to be captured)

* Technique #E-1: UE assistance information or feedback/report to further facilitate gNB network energy saving
  + Support of PUCCH transmission with negative SR report can be considered to aid gNB’s decision on whether to go into an energy saving state or not.
    - Support of UE’s mobility status and location can be considered to aid gNB’s perform energy saving techniques
  + [UE assistance information including CG-PUSCH transmission information, traffic relation information, such as pattern, volume etc.]
  + [UE report of certain measurement, e.g., based on discovery reference signal.]
  + [UE assistance data for gNB to assess whether it can go into an energy saving state, e.g. polling number of idle UEs, polling UEs beyond certain coverage.]
  + [UE request of SSB configuration]
  + [SR/CG PUSCH transmission indication]
  + Potential impact to other WGS
    - [To be filled]

### [CLOSED] 3rd Round Discussions

Based on comments received, and concerns on lack of clarity on some of the description for the UE assistance information, moderator suggest companies to provide necessary input into each of the other NW energy saving techniques.

If all companies agree, moderator will assume this discussion can be closed as the discussion contents will be absorbed by other discussions.

Please provide comments if you think a separate description and agreement on UE assistance information aspects is needed. If so, please also provide suggestions on how to modify Proposal #6-1B so that it could be more stable for agreement.

|  |  |
| --- | --- |
| Company | Comments |
| CATT | We don’t see the potential network energy saving from these proposals. We could further discuss if the proponents provide the evaluation results for justification. |

### [ACTIVE] 4th Round Discussions

Moderator asks companies to further provide any additional comments continuing from 3rd round.

|  |  |
| --- | --- |
| Company | Comments |
| - | - |

### Summary of 4th Round Discussions

No company raised concerns on discussing UE assistance information as part of time/frequency/spatial/power domain techniques.

Moderator assumes this discussion topic can be closed.

### == Discussion Closed ==

# Suggested Proposals for Agreement/Conclusion

#### Proposal #1-2 – GTW Check Needed

The following are description of a potential energy saving techniques being discussed in RAN1. The benefits and performance impact of the candidate techniques are subject to further RAN1 evaluations, while RAN1 consider the following techniques may have potential impact/need involvement on/from other WGs. The impact is not an exhaustive list nor represent definitive list of impacts to WGs and is subject to further changes as RAN1/RAN2/RAN3 progress work for the SI.

The description of the technique does not imply the technique will be automatically captured to the TR, but assumed to be the basis for the description in the TR if agreed.

#### Proposal #2-1G

* Technique #A-1 Adaptation of common signals and channels
  + Adapting the transmission pattern (when applicable) of downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the transmission pattern/availability of uplink random access opportunities.
  + Background:
    - In Rel-15 NR, time-domain positions of transmitted SSBs within a half frame are semi-statically configured. Further, UE assumes a single periodicity for the transmitted SSBs. Transmission of common signal and channels or reception of random-access signals may make it difficult for gNBs (with very low or no traffic) to better utilize the increased inactivity periods for entering deeper sleep modes to save energy.
    - Currently, SI update mechanism can adapt the parameters in the cell, such as those associated with downlink common and broadcast signals, such as SSB/SI/paging/cell common PDCCH, and/or the periodicity/availability of uplink random access resources.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * The UE network access performance requirements in RAN4 may get impacted by adaptation of common control and broadcast channels.
      * The UE measurement performance based on SSB may be affected.

#### Proposal #2-2H

* Technique #A-2: Dynamic adaptation of UE specific signals and channels
  + Reducing/omitting time occasions for the UE specific resources during periods of low activity.
    - Potential list of UE specific resources are CSI-RS, group-common/UE-specific PDCCH, SPS PDSCH, PUCCH carrying SR, PUCCH/PUSCH carrying CSI reports, PUCCH carrying HARQ-ACK for SPS, CG-PUSCH, SRS, positioning RS (PRS).
  + Background:
    - The semi-static configured UE specific channels/signals may require gNB for periodic transmission or reception if they are activated. Dynamic adaptation of transmission or reception of signals/channels may provide more opportunities for gNB to enter inactive state.
    - Except for positioning RS (PRS), the configu-rations for the listed UE-specific sig-nals/chennels are BWP-specific, and BWP adaptation framework can be utilized for dy-namic adaptation
  + Potential impact to other WG
    - RAN2:
      * UE measurement procedure based on periodic CSI-RS
      * Configuration and procedures related to enhanced dynamic adaptation of one or more UE-specific signals/channels
    - RAN3:
    - RAN4:
      * Performance requirements of measurements based on periodic CSI-RS

#### Proposal #2-3G

* Technique #A-3: Wake up of gNB triggered by UE wake up signal (WUS)
  + UE can send an uplink signal to request transitioning of a gNB inactive state to an active state for transmitting or receiving a channel/signal. The technique can be applicable to UEs in one or more RRC states. The UE WUS may be used to trigger the SSB/SIB transmission.
  + Can be used in support of other techniques. Exact design may depend on the supported technique.
  + Background:
    - With the support of WUS, the gNB might go to an inactive state (where it does not transmit nor receive signal/channel or where it only transmits and receives limited signals) outside of the WUS monitoring occasions. A gNB in an inactive state can transition to an active state for transmitting or receiving a channel/signal upon reception of an uplink signal from the UE.
  + Potential impact to other WG
    - RAN2:
      * Signaling details of wakeup configuration
      * Conditions to trigger WUS transmissions, and any WUS transmission related procedures and behaviors.
    - RAN3:
      * WUS configuration exchange across neighboring gNBs
      * Coordination on determination of gNB state across neighbor gNB that receive WUS
    - RAN4:
      * Feasibility of obtaining time/frequency synchronization and power setting for UEs that are sending WUS to the gNB that does not transmit SSB.

#### Proposal #2-4H

* Technique #A-4: Adaptation of DTX/DRX
  + With DTX/DRX, gNB has the opportunity to be inactive. During the inactive duration, gNB does not need to transmit or receive some periodic signals/channels, such as common channels/signals or UE specific signals/channels, and may have no transmission/reception or only keep limited transmission/reception.
  + Enhancement of UE C-DRX where DRX cycles or offsets configured for UEs in connected mode or idle/inactive mode can be aligned, potentially provide longer inactivity periods at the gNB and reduce gNB’s activities (e.g. SSB, CG PUSCH, RO, etc.) outside UE DRX active time.
  + gNB entering into inactive state for a period of time along with the possible indication of network adaptation of DTX/DRX.
  + Background:
    - In case of DTX/DRX the BS can go to inactive state with different time granularities. Currently C-DRX is configured per UE, and the DTX period for one UE may be active time for the other UE, depending on scheduler. In this case, gNB has to schedule different UEs on different time periods, and the time left for its inactivity will be limited. The alignment of the DRX cycles or offsets for the UEs can be done only via RRC re-configuration. Potential DTX/DTX enhancements to increase inactive time for gNB can be studied.
    - Since UE may monitor certain channels/signals from BS when outside DRX active time, there may be corresponding restriction to BS activity time.
  + Potential impact to other WGS
    - RAN2/RAN3:
      * gNB DTX/DRX patterns/parameters definition and potential gNB DTX/DRX patterns exchange across neighbor gNBs.
    - RAN4:

#### Proposal #2-6H

* Technique #A-6 Adaptation of SSB/SIB1
  + On-demand SSBs/SIB1 transmissions may also enable long periods of inactivity at the gNB to achieve gNB energy saving.
  + SSB/SIB1 transmission on the serving cell can be triggered by on-demand SSB/SIB1 request.
  + The UE may obtain system information from other carriers/cells for such carrier/cell(s) and synchronize either from other carriers/cells or from a simplified signals transmitted on the same carrier.
  + Background:
    - Current specification supports SSB/SIB1-less operation for intra-band CA, where UE re-trieves system information and synchroniza-tion from another intra-band cell with SSB and SIB1.
  + Potential impact to other WGS
    - RAN2:
      * The event trigger and higher-layer UE procedure of on-demand SSBs/SIB1
      * Handling of transmissions of SIB1 if SIB1 transmission cycle is changed.
      * System information enhancement to provide other carriers’ information and carrier selection principles for UE.
      * For on-demand SSB/SIB, the introduction of uplink trigger signal may impact the procedure in which UE access the cell with on-demand SSB/SIB.
      * For SIB-less carrier/cell, SIB1 enhanced to carry necessary SIB information for other cell, UE cell (re)selection procedures, and SSB/SI acquisition from an anchor cell for inter-band CA case.
    - RAN3:
    - RAN4:
      * feasibility of only on-demand SSB transmission for time/frequency synchronization.
      * RLM and RRM measurements from on-demand transmission of SSB.
      * network access performance requirements impacted by on-demand SSBs/SIB1.
      * measurement performance based on SSB

#### Proposal #3-1H

* Technique #B-1: Multi-carrier energy savings enhancements
  + Background:
    - Intra-band SSB-less Scell operation has already been supported by the current specification
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell, procedures similar to legacy Intra-band SSB-less Scell operation may be investigated.
  + Inter-band CA with SSB-less carriers/Scell
    - No SSB transmission in some inter-band SCell. The sync is acquired from other cell with SSB transmission or same cell with simplified signal transmission, also in order for fast activation and deactivation of SCell.
    - Enabling of Inter-band SSB-less Scell operation that may include mechanism for UE to trigger normal SSB transmission on a SCell for fast access, where the on-demand uplink triggering signal can be received either at inter-band SSB-less cell or another carrier/cell, and supporting RACH transmission opportunity in SSB -less Scell.
  + Dynamic UE-group Pcell switching
    - To reduce network power consumption, a common primary cell may be dynamically indicated for a group of UEs.
  + Potential impact to other WGS
    - RAN2:
      * For inter-band CA with SSB-less Scell:
        + RACH procedures in SSB-less Scell
      * Impact on procedure for dynamic Pcell switching
    - RAN3:
    - RAN4:
      * Feasibility of inter-band SSB-less Scell

#### Proposal #3-2F

* Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier
  + Enhancements to enable UE group-common or cell-specific BWP configuration and/or switching.
  + Enhancements to support SPS PDSCH reception/Type-2 CG PUSCH transmission/SP-CSI reporting on PUSCH without reactivation after the BWP switching.
  + Background:
    - In Rel-17, UE-specific BWP configuration and switching is supported.
    - For SPS PDSCH reception, type-2 CG PUSCH transmission, and SP-CSI reporting on PUSCH, once BWP is switched, they should be reactivated by activation DCI.
  + Potential impact to other WGS
    - RAN2:
      * Impact on BWP switching procedure and configuration for UE group-common or cell-specific BWP.
    - RAN3:
    - RAN4:

#### Proposal #3-3F

* Technique #B-3: Dynamic adaptation of bandwidth of active BWP
  + Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP. Some frequency resources within the active BWP may be deactivated.
  + Background:
    - Currently, a bandwidth of a BWP is semi-statically configured, and the bandwidth of the given BWP cannot be dynamically changed. Thus, dynamic adaptation of bandwidth of UE(s) within a BWP is not supported by the existing spec.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:

#### Proposal #4-1H

* Technique #C-1: Dynamic adaptation of spatial elements
  + The techniques aims to dynamically adapt spatial elements such as the number of active transceiver chains or the number of active antenna panels at gNB in transmitting and/or receiving channels and signals.
  + Potential enhancements include the mechanisms to indicate spatial element adaptation to the UEs and the mechanisms to trigger gNB to switch between different spatial domain configurations, including e.g., enhanced CSI-RS configuration, CSI measurement and feedback, signaling for the spatial element adaptation for SSB.
  + Background:
    - Indication for potential enhancements related to spatial element adaptation may help the UEs to adapt the already configured CSI-RS configuration such as dynamic/semi-persistent ON-OFF of CSI-RS or to reconfigure the CSI-RS configuration, with respect to adapted number of spatial elements/ports.
    - CSI-RS and CSI reporting configurations are BWP-specific, and BWP adaptation frame-work can be utilized for the adaptation.
  + Potential impact to other WG
    - RAN2:
      * Signaling to trigger the change of spatial element configuration to UEs.
      * Impact to mobility due to dynamic spatial adaptation of CSI-RS/SSB.
    - RAN3:
    - RAN4:
      * RLM or RRM measurement from adaptation changes to spatial element configuration.

#### Proposal #4-2G

* Technique #C-2: TRP muting/adaptation in multi-TRP operation
  + For a UE configured with multiple TRPs, TRP activation/deactivation can be informed to the UE. The technique aims to dynamically adapt the number of TRPs transmitting and/or receiving signals and channels.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:

#### Proposal #5-1G

* Technique #D-1: Adaptation of transmission power of signals and channels
  + The technique aims at adaptaing the transmission power or PSD of downlink signals and channels
  + Background:
    - Adaptation of transmission power of signals and channels is a technique that allows the gNB to dynamically adjust the transmit power of one or multiple downlink signals/channels. The technique may be applicable to PDSCH, CSI-RS, DMRS, broadcast channels/signals (e.g., SSB/SI/paging).
    - The power offset configurations for PDSCH, CSI-RS and DMRS are BWP-specific, and BWP adaptation framework can be utilized for the adaptation of the settings.
  + Potential impact to other WGS
    - RAN2:
      * Possible impact on mobility due to dynamic power adaptation of CSI-RS/SSB
      * Configuration and signaling of indication of power related parameters to the UEs
    - RAN3:
    - RAN4:
      * Depending on the change in PSD to certain signals that are multiplexed together, some input from RAN4 may be needed, for example, spectral flatness (RE power control dynamic range) and other output power related aspects

#### Proposal #5-2G – GTW Check Needed

* Technique #D-2: enhancements to assist gNB digital pre-distortion
  + Enhanced over the air digital pre-distortion at the gNB
  + Background:
    - In gNB digital pre-distortion over the air, the UEs assist the gNB in reducing nonlinear impairments introduced by the PA, by processing (e.g., calculation of the cross correlation of received signal after applying non-linear kernels) and reporting the information needed for gNB digital pre-distortion, on training signals.
    - Note that some companies pointed out gNB may be able to implement digital pre-distortion in a standard transparent manner.
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * Investigation on UE requirements from support of post-distortion
      * Investigation on the required change in BS RF requirements from relaxation of pre-distortions
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

#### Proposal #5-3G

* Technique #D-3: adaptation of transceiver processing algorithm
  + Tone reservation that decreases PAPR, potentially taking into account channel conditions and characteristics
  + Background:
    - Tone Reservation exploits the channel nulls to carry TR tones, potentially taking into account channel conditions and characteristics. The UE must be notified of the sub-carriers carrying the TR signal for rate matching purposes.
    - gNB may opt to use different transceiver processing algorithms, e.g. different receive filtering, different transmitter digital pre-distortion methods, etc,, including some that may favor lower power consumption at the expense of degraded system performance. For example, disabling use of DPD that would potentially increase out of band emissions or tx EVM, but would potentially conserve transmitter power consumption.
  + Potential impact to other WGS
    - RAN2:
    - RAN3:
    - RAN4:
      * RF requirements either at gNB or UE.

#### Proposal #5-4G – GTW Check Needed

* Technique #D-4: PA backoff adaptation
  + Technique(s) allowing to modify/reduce the input bias backoff in cases of no or low load in the cell and in neighbor cells.
  + Background:
    - In current networks, when the DL traffic is zero, the network goes to sleep. In case of very low or low load, the PA can adapt/reduce its backoff reducing thus the PA power consumption. It is widely known that adapting/reducing the PA backoff results in unwanted in-band and out-of-band emissions. Therefore, neighbor cells with UEs which could have been affected from an eventual PA backoff of a given neighbor BS PA are going to sleep mode, during the duration of BS PA backoff adaptation. Hence, BS PA backoff adaptation for few msecs, in the order of micro or light sleep, or deep sleep, are suggested. In this way, UEs in neighbor cells are protected from any eventual in-band and out-of-band unwanted emissions.
    - The effect of BS PA backoff adaptation is less at FR 2 due to narrow beams
  + Potential impact to other WG
    - RAN2:
    - RAN3:
      * coordination between BSs adapting their PA backoff and neighbor BSs whose UEs might be eventually affected
    - RAN4:
      * Depending on the change in power loaded to RE, some input from RAN4 on spectral flatness (RE power control dynamic range) and other output power related aspects
      * Assessment of impact from various BS PA backoff levels onto unwanted in-band and out-of-band emissions.
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

#### Proposal #5-5C – GTW Check Needed

* Technique #D-5: UE post-distortion
  + UE performing received signal post-distortion processing (e.g. non-linear equalization stage that will “invert” the non-linearity) to combat non-linear impairments from the transmitter.
  + Transmission of reference signals or information to aid the UE to perform post-distortion processing.
  + Background:
  + Potential impact to other WG
    - RAN2:
    - RAN3:
    - RAN4:
      * UE requirements from support of post-distortion may be needed
      * Note: Some companies expressed opinion that RAN4 input is needed for this technique in order for RAN1 to evaluate and assess the technique.

# Additional Information for Each Technique

This section includes additional information that were not part of the proposed agreement, but serves useful information for companies to use to better understand the potential techniques for evaluations.

Moderator assumes the following information could be further updated and text, such as potential specification impact and other information, can be eventually captured into the TR.

##### Technique #A-1 Adaptation of common signals and channels

* + Potential specification impact:
    - UE behavior for network access, such as initial access, measurements, RRM, and mobility, when informed about adaptation of common signals and channels. There is need to relax UE requirements to accommodate longer access or failure report latency, lower measurement accuracy and higher handover failure rate, due to the reduced availability of common channel/signals.
    - Mechanism on how UE can be informed about adaptation of common signals and channels
    - For adapting periodicity/availability of uplink random access opportunities, specification impact includes provisioning of adaptable RACH opportunities for Rel-18 UEs and associated RACH procedure.
    - DL indication mechanisms to inform UE of adaptation of common signals and channels.
    - Impact to TTI of system information blocks in RAN2 is expected if longer periodicities of SSB or SIB1 are to be supported.
    - Impact to paging occasion and paging frame definition in RAN2 is expected if enhancements to paging are to be supported.
    - Enabling UEs to adapt to the varying periodicity or transmission pattern of the common signals or channels; e.g., specification enabling UEs to enhance initial access performance to counter the impact due to increased SSBs/SIB1 periodicity.
    - Mechanisms to indicate/trigger the adaptation of the periodicity and/or a transmission pattern of downlink common and broadcast signals, including assistance of DL indication from network, UL WUS sent from UE
    - Impact on UL RO
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The legacy UEs may not operate in the cell with this technique. Legacy UEs may not recognize the adaptation of common signal and channel; e.g., initial access of legacy UEs expecting 20 ms SSB periodicity might fail with an increased SSB periodicity.
    - The UE assumptions on the measurements on the SSB by legacy UE for initial access, RLM, and RRM for mobility may get impacted.
    - The potential UE transitions to out-of-sync state when the periodicity of SSB is longer than the minimum duration in RAN4, e.g., 160 ms.
    - For adapting periodicity/availability of uplink random access opportunities, there is no impact to legacy UEs.
    - Legacy UE’s behavior for cell detection, RRM and RLM measurements, and random access do not change. Network implementation may avoid potential impact on legacy UEs by employing adaptation properly.
    - Since the reduction common channel/signals, providing longer inactivity at the gNB, might have impact to the UE normal access to the network, such as initial access, measurements, RRM, mobility, and legacy UE network access.
    - Cell measurement is related to SSB periodicity. If legacy UE cannot be indicated the change of serving/neighbor cell SSB periodicity (due to new adaptation mechanism), there is impact to measurement accuracy (if UE cannot detect the correct periodicity) or longer latency for measurement outcome or hand-over, which can cause mobility performance degradation to legacy UE.
    - Legacy UE determine paging/cell common PDCCH occasions based on SIB1 configuration. If a new adaptation mechanism other than SI update mechanism is introduced, it is possible legacy UE cannot be notified of the change, and PO and common PDCCH monitoring will be failed.
  + The following options are various methods of adaptation for Technique #A-1a.
    - Option 1) introducing simplified version of downlink common and broadcast signals, such as only PSS or only PSS and SSS without PBCH, or PSS and SSS with partial PBCH
    - Option 2) Different repetition periods for different common channels, e.g. SSB, SIB1 PDCCH/PDSCH
    - Option 3) Transmission occasion of one or more common signals/channels of specific periods can be skipped.
    - Option 4) Burst transmission and reception of common signals and channels with multiple configured periodicities, each periodicity configured for each subset within the burst of common signals and channels, more than one periodicity are expected to potentially provide longer inactivity periods for the gNB.
    - Option 5) Support of configuration of longer periodicity (than what is currently supported) of common signals and/or uplink random access opportunities
    - Option 5a) Provisioning of additional uplink random access opportunities for Rel-18 UEs.
    - Option 6) The varying periodicity and/or dynamically changing a transmission pattern is indicated by DL signaling, or triggered by WUS sent from UE, or conditionally triggered.
    - Option 7) Adaptation of transmission patterns include switching between uniform and non-uniform spacing between transmission occasions of common or broadcast signals. For example, instead of configuring paging frames (PFs) with a uniform spacing within the DRX cycle, PFs can be placed in a contiguous manner while keeping the same paging information transmission opportunities within the DRX cycle. Similarly Ros can also adjusted, e.g., configured in a compacted manner, so that longer inactivity periods can be observed at the gNB.
    - Option 8) Adaptation mechanisms include semi-static such as by SIBx or DCI based indication to switch between different configurations.
    - Option 9) Simplified DL signals in lieu of SSBs or prior to SSBs to improve the initial access performance significantly while letting the periodicity of transmission be large enough for NES, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.
    - Option 10) support of a long period (rather than the period as the same as the SSB period) of search space
    - Option 11) support of scheduling of SIB1 by SSB to avoid transmissions of DCIs within CORESET 0, support of the mechanism to reduce impacts on SSB and overhead

##### Technique #A-2: Dynamic adaptation of UE specific signals and channels

* + Potential specification impact:
    - gNB may enter into sleep mode for a period of time along with the indication of network energy saving or non enery saving state, e.g., in terms of start time and duration.
    - UE assistance information report
    - Dynamic signaling design to reduce transmission of these UE specific channels/signals, by utilizing UE/cell group-level or cell common signaling to allow gNB to minimize configuration overhead and potentially minimize overall gNB activity.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not able to use resources in all network energy saving states.
  + Reduction of time occasions or synchronization of UE specific signal/channels can be performed based on following options:
    - Option 1) RRC configures whether to receive/transmit a channel per configuration when gNB is in sleep mode.
    - Option 2) UE specific, and group common signaling that indicates to UEs to temporarily stop the transmission/reception of semi-statically configured channels/signals

##### Technique #A-3: Wake up of energy saving gNB triggered by UE wake up signal (WUS)

* + Potential specification impact:
    - If a gNB is in energy saving state, the UE may not be able to transmit periodic/semi-persistent UL channels. For UL latency sensitive traffic, the latency requirements may not be satisfied if the energy saving state is not properly configured/indicated.
    - Uplink signal design & related procedure for waking up a gNB
    - WUS signal/channel design
    - Mechanism on how UE can be informed about WUS signal/resource
    - UE measurements of PL of the gNB in the NES state for the UL power setting of UL WUS
    - UE behavior/assumption after sending WUS
    - Conditions for triggering the request, e.g., DL synchronization
    - Signaling for the request
    - UE behavior after transmitting the request
    - Specification enabling UEs to obtain necessary DL synchronization and measurements prior to the WUS in the uplinkDesign of WUS transmitted by UE
    - Conditions for triggering WUS transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is assumed that UE is synchronized with the gNB in the NES state or the gNB in the NES state is provided with timing information for detection of WUS.
  + Additional aspects of waking up gNB
    - Option 1: UE WUS is used to wake up a gNB in an energy saving state without DL transmission including SSB/SIB1 and UL reception including RACH monitoring (i.e., cell off/inactive period), or with sparse SSB/SIB1 transmission and RACH monitoring (e.g. 160ms)
      * UE may send WUS when moving to the coverage of this energy saving cell or there is need for fast access/synchronization/measurement
      * The WUS may trigger gNB’s normal operation, i.e. normal SSB/SIB1 transmission and RACH monitoring (e.g. 20ms)
      * UE reads SSB/SIB1 and perform random access if applicable after transmitting WUS
    - Option 2: UE WUS is used to wake up a gNB in an energy saving state without reception of semi-static UL transmissions
      * Wake up signal (WUS) is triggerd by MAC layer.
      * UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.
    - Support of assistance information such as mobility, location information from the UEs either directly or tought the anchor gNB intended to aid wake up operations by the gNBs.
    - DL synchronization needed for the UL WUS transmission may be obtained via the simplified DL signals in lieu of SSBs defined in technique #A-1 to aid initial access.
    - The WUS in UL can also be used to change SSB periodicity from a large value (e.g. 160 ms) to a regular value (20 ms).
    - Wake up signal (WUS) is triggerd by MAC layer.
    - UE transmits semi-static configured UL channels X symbols after transmitting gNB wake up request or UE monitors PDCCH carrying an ACK for gNB wake up request after transmitting gNB wake up request.

##### Technique #A-4: Adaptation of DTX/DRX

* + DTX offset configuration at gNB
    - Offset value can be aligned with or close to SS burst location so as to minimize total BS active time for transmitting UE data and common channels/signals
  + DTX/DRX cycle configuration/pattern at the gNB
    - This may include potential enhancements to UE behavior when both cell-specific DTX/DRX cycle and UE DRX cycle are configured.
    - Transmission and reception of some common/signals, e.g. PRACH, can be adjusted to match the DTX/DRX pattern at the gNB.
    - Joint or separate configuration of DTX and DRX mode at the gNB is considered.
    - Periodic DTX is assumed as a baseline. The gNB provides indication to UE about NW DTX mode/configuration via dedicated dynamic L1/L2 signaling. Dynamic L1/L2 group signaling from NW to provide NW DTX mode/configuration.
    - cell-specific DTX/DRX operation may be different between Idle mode and connected mode
    - This may include association between WUS for gNB and the cell-specific DTX/DRX
  + Controlling UE DRX on/off periods for multiple DRX cycles with a single indication
  + The technique may include UE-specific indication, group level indication for, such as UE-group signaling or cell-specific signaling, UE DRX commend such as DRX enhanced MAC CE and long DRX commend MAC CE. Cell-specific signaling can be based on paging PDCCH or paging early indication (DCI format 2\_7).
  + gNB sleep mode indication may include start time and duration of one or multiple following BS states or the indication remains valid until overridden by another indication.
    - Energy-saving state 1: the UE doesn’t transmit/receive any signal/channel;
    - Energy-saving state 2: the UE only transmits/receives a particular set of signal/channel
  + gNB sleep mode indication may include monitoring occasion for the next gNB state indication.
  + If gNB enters into sleep mode, the UE doesn’t transmit/receive any signal/channel or only transmits/receives a particular set of signal/channel.
  + Potential specification impact:
    - when the network pauses transmission, common control channels as well as CSI-RS used for either mobility or for other purposes.Introduction of mechanism/signaling to enable inactive opportunity for gNB
    - Configuration and indication of gNB’s DTX/DRX information to UE
    - UE behavior/procedure when gNB’s DTX/DRX is in operation
    - Defining DTX/DRX pattern for gNB.
    - Mechanisms to align C-DRX configuration of UE, such as signaling design to align the C-DRX configuration.
    - Mechanism to wake up gNB from DTX/DRX
    - Configuration and indication of gNB’s DTX/DRX cycle information to UE
    - UE behavior/procedure when gNB’s DTX/DRX cycle is in operation
    - Design of DTX/DRX pattern
    - Adaptation of DTX/DRX by DL indication/WUS triggering
    - Impact on periodic signal/channel transmission
    - A set of cell-specific DRX configuration, including at least DRX offset value(s), in SIB
    - A mechanism of triggering adaptation for UE to align with the indicated cell-specific DRX configuration, e.g. DRX offset value
    - Configuration of DRX cycle aligned with the DTX/DRX cycle configuration/pattern used at the gNB for network energy saving
    - Dynamic L1/L2 indication to UE on the DTX mode/configuration applied at gNB and/or for switching to a DRX cycle corresponding to network energy saving
    - impact on preconfigured operations at the UE such as Harq codebook, SSB etc
      * UE transmit/receive by resuming the preconfigured operation upon gNB switching ON
    - Mechanism for indicating the network energy states in current or future time periods.
    - The technique may include support of semi-static and/or dynamic gNB active/inactive state adaptation.
    - The technique may include group common signaling for the indication of adapted active/inactive state
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Impact from gNB DTX/DRX onto legacy UEs has to be assessed. Impact onto Rel. 18 idle/inactive UEs can be kept to zero if the gNB performs DTX outside of SSB/SI transmission instants. The same applies when gNB performs DRX outside the RO slots.
    - For, introduction of mechanism/signaling to enable inactive opportunity for gNB,
      * when it is done in a UE-specific manner(e.g. for connected mode Rel-18 UEs), no impact to legacy UEs.
      * when it is done in a legacy UE-transparent manner(e.g. for legacy UEs in idle and/or connected mode), no impact to legacy UEs.
    - N/A since if legacy UE’s DRX offset cannot be adjusted by the new adaptation mechanism, gNB is expected to reconfigure UE’s DRX setting or accommodate UE’s active time durationsLegacy UEs may incur longer access delays or unable to access the cell in some gNB inactive states.

##### Technique #A-6 Adaptation of common signals and channels

* + The following options are other various methods used together with on-demand SSB/SIB or SSB/SIB1-less operation:
    - Option 1) DL signals to aid initial access and discovery of cells in lieu of SSBs.
    - Option 2) mechanism for UE to trigger on-demand SSB/SIB1 transmission, for example, by sending WUS, for fast access/fast cell activation/synchronization/measurement.
    - [Option 3] cross carrier synchronization and system information enhancement to provide other carrier/cell’s information and random access carrier selection principles for UE to realize access a different carrier rather than carrier it gets SSB/SIB1.]
      * [moderator note: Repeat of #3-1B?]
    - [Option 4] offloading SIB of the SIB-less cell to another cell. And SIB-less operation is for non-CA case.]
      * E.g., UE on SIB-less cell can obtain SIB via common channels transmitted on another cell.
      * [moderator note: Repeat of #3-1B?]
    - Option 5) Simplified DL signals in lieu of SSBs providing necessary synchronization prior to the UE trigger for on-demand SSBs/SIB1 and potentially enhancing initial access performance altogether significantly, e.g., simplified DL signals that indicate the presence of gNBs transmitting SSBs within a limited block of frequency positions.
  + Potential specification impact:
    - On-demand SSB/SIB1 transmission or SSB/SIB1-less operation might have impact to the behavior of wUEs for network access, such as initial access, measurements, RRM, mobility, and so on.
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - Conditions and procedures on how UE sends on-demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - The UE assumptions and behavior of SSBs/SSB1 transmission for on-demand or no transmission of SSBs/SIB1 need to be specified
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Details of on-demand triggering, including the triggering signaling design, triggering signaling configuration, and the triggering procedure.
    - Cross carrier synchronization for single carrier operation
    - System information enhancement to provide other carriers’ information and carrier selection principles for UE
    - Reduced or no availability of SSBs/SIB1 would result in performance degradation in terms of UE normal access to the network, such as initial access, measurements, RRM, mobility and so on.
    - Specification enabling UEs capable of performing initial access with on-demand SSBs/SIB1 transmission, e.g., defining simplified DL signals preceding a UE trigger to aid initial access and discovery of cells in lieu of regular SSBs
    - Mechanism on how UE can be informed about configuration for on-demand SSB/SIB1 request
    - DL signaling mechanism that enable UE to synchronize with the gNB for sending the on demand SSB/SIB1 request
    - UE behavior/assumption after UE sends on-demand SSB/SIB1 request
    - For on-demand SSB/SIB, the potential specification in RAN1 may include:
      * Uplink trigger signal design
      * Downlink signal/channel [which is to aid initial access and discovery of cells in lieu of SSBs] design, if supported.
      * SSB-less carriers operation is used for inter-band CA. Due to the fact that SSB-less carriers operation is already supported in intra-band CA, the existing procedure in RAN1 defined for intra-band case can be re-used in general.
      * For SIB-less carrier, there is no obviously specification impact in RAN1.
    - Signaling design for on-demand SSBs/SIB1 transmission indication, UE’s or network’s behavior in response to the on-demand indication, etc.
    - System information enhancement to provide other cell’s information and cell selection for UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The potential impact of RRM/RLM measurements and network access delay by UEs.
    - Impact on legacy UEs: legacy UEs might not recognize such a technique.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UE unable camp or perform initial access on cell with long periods of inactivity
    - Whether this technique is applicable to Connected, Inactive, or Idle mode

##### Technique #B-1: Multi-carrier energy savings enhancements

* + Potential specification impact:
    - Specification impact includes impact on RRM/CSI measurement and how UE can be informed about resource for on-demand or WUS type of uplink triggering signal
    - Clarify QCL source for receiving/transmitting channels especially when QCL source is related to SSB
    - Mechanism to trigger SSB transmission or simplified SSB transmission in the SSB-less Scell (e.g., by using some uplink signal)
    - L1/L2 signalling to indicate primary cell change to a group of UEs
    - Operating cells without or with reduced transmission and reception of periodic signals and channels such as SSB at the gNB, might have impact to the UE normal access to the network, such as measurements, RRM and mobility.
    - For supporting of Inter-band SSB-less Scell operation, in case of the cross-carrier synchronization and/or measurement via another serving cell cannot be performed, there may include mechanism for UE to trigger normal SSB transmission on a SCell, where the on-demand or WUS type of uplink triggering signal can be transmitted at another serving cell.
    - Operation of Scell without SSB may include varying the periodicity and/or a transmission pattern (when applicable) of SSB, the periodicity of uplink random access opportunities, and support of simplified/modified version of SSB, e.g., where one or more of PSS/SSS/PBCH can be skipped.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Hardware architecture needs to be carefully considered. For shared hardware components among carriers, switching off or disable one of the carriers may not bring benefits to the network energy saving, since the shared hardware components are still utilized by other active carriers.
    - Reserve carriers dedicated for backward compatibility serving as a coverage and mobility layer and supporting legacy UEs so that other carriers on NES mode need not be discoverable.
    - The legacy UEs may not operate in the cell with this technique
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Signals/channels for UE request and L1 indication in L1 based SCell activation/deactivation
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
    - Specification impact includes enhancements on SCell activation procedure.
    - UE unable to camp on a cell without SSB/SIB in IDLE/Inactive states.
    - Legacy UEs are not expected to be able to access a cell with reduced transmission and reception of common periodic signals and channels
  + Additional aspects to be considered together with operation of SCells without or with reduced transmission of periodic transmission and reception are:
    - UE specific or UE group-common signaling to (de)activate SCell(s), and/or Pcell change
    - Enhancements to dormant BWP operation, e.g., extending dormant BWP to P(S)Cell or PUCCH-SCell or minimizing gNB’s activity with dormant BWP
    - Quick activation and deactivation of CC, for example, based on on-demand RS, aperiodic DL/UL RS, UE request, and L1 response and L1 activation command

##### Technique #B-2: Dynamic adaptation of bandwidth part of UE(s) within a carrier

* + The reduction of RF BW had shown the reduction in energy consumption in LTE e-MTC. The dynamic adaptation of Tx BW of gNB RF by BWP switching in a cell could achieve network energy saving.Potential specification impact:
    - Signalling details to support UE group-common or cell-specific BWP configuration and/or switching
    - Semi-static configuration of cell specific BWPs
    - L1 signaling in cell specific BWP switching indication
    - Signalling details to support UE group-common or cell-specific configuration and/or switching of BWP for network energy saving state
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The cell-specific BWP switching delay
    - Interaction of cell-specific BWP switching and legacy UE-specific BWP switching.

##### Technique #B-3: Dynamic adaptation of bandwidth of active BWP of UEs

* + Potential specification impact:
    - Signalling details to support group-common or UE-specific bandwidth adaptation
    - UE’s behavior that is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP
    - Enhancements to enable group-common signaling to adapt the bandwidth of active BWP and continue operating in same BWP.
    - Introduce some frequency resource scheduling restriction within the active BWP.
    - Clarify that UE is not required to receive DL signal/channel or transmit UL signal/channel configured/allocated for the deactivated frequency resource within a BWP.
    - Dynamic indication of an active bandwidth of an active BWP
    - Impacts on preconfigured operations (e.g. CSI-RS,configured grant, etc.) in deactivated portion of the active BWP
    - Signalling mechanism for adaptation of active BWP
    - Signalling of deactivated portion (e.g., in terms of number of RBs and starting RB)
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - No impact to legacy UE is expected, since network implementation can avoid any impact to legacy UE operation.

##### Technique #C-1: Dynamic adaptation of spatial elements

* + Adaptation can be further categorized into following types:
    - Type 1: enable/disable all spatial elements associated to a logical antenna port, e.g. a subset of ports of a CSI-RS resource (set).
    - Type 2: enable and/or disable of part of spatial elements associated to a logical antenna port(s).
    - Note: May need to consider power adaptation on the spatial elements associated with the antenna ports/RS configuration
  + Potential enhancements to UE behaviors due to dynamic port adaptation, e.g., measurements, CSI feedback, power control, PUSCH/PDSCH repetition, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc.
  + Techniques including conditions/criteria for UE measurements and feedback to gNB for (de)activation and/or adaptation of antenna ports.
    - For example, UE compares the rank/SINR/CSI levels of the current link to gNB configured thresholds. Once the UE detects that the condition is met, it can request/measure for additional reference signals for further measurement/reporting.
  + UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB.
    - optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses
  + UE feeds back indication to trigger spatial element adaptation
  + Potential specification impact:
    - The related changes in spatial domain caused by spatial element adaptation should be indicated/configured to the UEs for the spatial adaptation of gNB/cell power state. Mechanisms to trigger gNB/cell power state and to recover back into normal network power state should be supported.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Type 1 and Type 2, and Type 3 may have impact on measurement operation (if dynamic spatial elements adaptation will impact CSI-RS, SSB ...), so the potential enhancement may include
    - CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements, e.g. UE behavior enhancement.
    - Introduction of group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS.
    - This may include enhancements to CSI-RS/report configurations to contain multiple configurations for different gNB/cell operation states and dynamic triggering of one of such configurations.
    - Enhanced CSI measurement/reporting to support multiple CSI-RS resource measurement/reporting
    - Dynamic adaptation of spatial elements may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Signaling details to indicate changes of the number of active transceiver chains or spatial elements
    - Enhancements to CSI measurement and feedback, BRF, RLM, and RRM.
    - Support L1/L2 signalling to inform UE on parameter configurations (e.g., downlink power allocation, TCI state, RS for path loss measurement etc.) to be used with respect to the spatial parameter change.
    - Type 1 ~~and~~ Type 2, and Type 3 may have impact on measurement operation, so the potential enhancement may include CSI-RS and PL RS measurements, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure enhancements.
    - Introduction of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting, which may be RRC-based or MAC-CE based or by other physical layer indication.
    - CSI-RS/reporting reconfiguration to UEs for dynamic adaptation of spatial elements.
    - Optimized CSI reporting contents to provide compact CSI feedback for different muting hypotheses.
    - Support of light-weight mechanisms such as DCI/MAC-CE-based, that allow fast spatial domain related reconfiguration and group-common L1 signaling due to spatial element adaptation, such as dynamic/semi-persistent ON-OFF of CSI-RS within an active configuration.
      * Adaptation of subset/number of ports for CSI-RS resources can be efficiently indicated to group of UEs and indicating change by UE-specific/UE-group common signaling.
      * This includes dynamic adaptation of parameters associated with a NZP-CSI-RS resource such as powerControlOffsetSS, powerControlOffset, etc
    - UE feeding back antenna muting pattern recommendations to the gNB. CSI reporting enhancement on muted or adapted spatial elements/patterns, etc. should be considered for assistance information feedback to the gNB
  + Additional consideration/aspects (including any impact to legacy UEs, if any)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, if the technique is applied to the broadcast channels and signals, approaches such as power boosting should be considered to guarantee cell coverage.
    - Type 2 adaptation may result in changes to the antenna pattern, gains, TCI states, and/or transmission power of the reference signal or channel that uses the antenna port(s)
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.

##### Technique #C-2: Dynamic adaptation of TRPs in mTRP

* + This may also include signaling of the adaptation of TRPs in mTRP, e.g. by utilizing group-level or cell common signaling.
  + Potential specification impact:
    - Technique may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - Support enhancements to UE behaviors due to dynamic adaptation of TRPs, e.g., measurements, CSI feedback, power control, PDCCH/PUCCH/PUSCH/PDSCH repetition, single-DCI based scheduling, multi-DCI based scheduling, SRS transmission, TCI configuration, beam management, beam failure recovery, radio link monitoring, cell (re)selection, handover, initial access, etc
    - Signaling details to indicate muted TRP, e.g., based on TRP index or CORESET pool index
    - Type 3 may have impact on redundant CSI measurement or reporting to a muted TRP, so enhancement may include dynamic signaling for TRP ID (CORESETPollIndex).
    - Enhancements to CSI measurement and feedback,
    - L1/L2 signalling to inform UE on update for TRP-related parameters due to dynamic TRP on/off.
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - The change in spatial elements may significantly impact the coverage of the cell due to possible reduction in beamforming gain and total downlink transmission power, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals especially when the adaptation of the spatial elements is applied across active TRPs.
    - It is desired that enhanced beam reporting maintains same or similar configuration signaling overhead and measurement time compared to Rel-17 group based beam reporting.

##### Technique #D-1: Adaptation of transmission power of signals and channels

* + signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
  + This may include enhancements on UE L1/L3 measurements and L3 filtering behavior due to power adaptation, ~~such as~~ beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
  + Different network nodes within a cell transmit different sets of SSBs with different SSB transmission power based on multiple SSB burst configurations in the cell.
  + This may include resource based variation of DL power for various signals & channels
  + The transmission bandwidth may be adapted jointly with transmission power to keep the similar reception performance.
  + UE feedback information, e.g, CSI reporting, power adjustment indication, etc, to assist gNB downlink power adaptation
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
  + Potential specification impacts are:
    - Configuration/re-configuration enhancement of UE-specific/group-based reconfiguration of various reference signal resources, measurement, reporting (if daynamic transmission power adaptation is applicable to the reference signal)
    - Signalling details to indicate the transmission power or PSD of DL signals and channels, e.g SSB, CSI-RS, PDSCH
    - Enhancements on CSI/RRM measurements, beam management, beam failure recovery, radio link monitoring, cell (re)selection and handover procedure
    - Enhancements to CSI measurement and feedback
    - Signalling to inform UE on the transmission power change
    - Signaling of modified power ratio between CSI-RS and PDSCH/SSB or between SSB and CSI-RS to provide adaptation of power ratio values, e.g. by utilizing UE-specific, group-level or cell common signaling.
    - Report multiple CSI, and each corresponds to a different power offset (hypothetical power offset between CSI-RS and PDSCH) in one CSI report
    - Need of UE assistant information, e.g.
      * Enhanced CSI report, e.g. report multiple CSI, and each corresponds to a different power offset(hypothetical power offset between CSI-RS and PDSCH) in one CSI report, with corresponding CSI-RS/CSI report configuration enhancement
      * power adjustment indication
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Downlink transmission power reduction may significantly impact the coverage of the cell, which impact coverage and network access of the UEs (both legacy and R18 UEs). Therefore, the technique is not applicable to the broadcast channels and signals.

##### Technique #D-2: enhancements to assist gNB digital pre-distortion

* + Enhancements to assist [gNB digital pre-distortion] (DPD-OTA):
    - Justification: digital pre-distortion (DPD) operation requires coupling the Tx output to an Rx feedback chain to capture the non-linearity and estimate it. Beamformed multiple antennas designs, especially in higher bands (i.e., FR2), present new challenges making DPD training at Tx side difficult, as the receiver sees the composite equivalent non-linearity which is the result of all PA’s working in non-linear operating point and summed by the beamforming weighting. DPD needs to capture distortions on the far field beam and not per individual PA in order to account for cross coupling PA NL effects. These effects are not seen in DPD’s Tx coupling feedback
    - Overview: UEs feedback DPD information based on their received signals. The UEs receive training signals in their respective beams, and process the information needed for gNB DPD. The computation schemes of the UE are vast, offering a range of performance and complexity tradeoff. One of them is calculation of the cross correlation of received signal after applying different non-linear kernels to it. The UEs will report the required information over a feedback channel. The gNB will then use the results for post-processing and calculating the DPD coefficients
    - Specification impact:
      * Capability of UEs to support DPD-OTA, activation of DPD process (measurement and reporting of enhanced CSI-RS)
      * Configuration of a set of non-linear kernels by the NW
      * Introduction of measurements and reporting of DPD information (e.g., non-linear kernels) to assist gNB’s DPD
      * Enhancements to CSI-RS, such as transmission of nonlinear CSIRS (with low PAPR and higher transmit power), and possibly allocating a larger BW than the one consisting of the CSI-RS
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of non-linear kernels, enhanced CSIRS)
    - Introduction of measurements and reporting of DPD information (e.g., report best non-linear kernel out of a list)
    - Introduction of CSI-RS enhancements (e.g., high power low PAPR transmission, rate matching around additional BW than the CSI-RS)
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new CSI-RS. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of power amplifier models)
    - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.
    - Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

##### Technique #D-3: adaptation of transceiver processing algorithm

* + Channel Aware tone Reservation
    - Justification: Tone reservation is a known method that introduces specific tones in a subset of allocated sub-carriers to reduce the PAPR of a transmitted waveform. This PAPR reduction is used to reduce the power consumption of the gNB. Channel aware Tone Reservation exploits the channel nulls to carry those tones and provide additional 1-1.5dB gain over non channel aware TR (and a total of 2.5-3 dB gain over non-TR transmission).
    - Overview: In order to support channel aware tone reservation, where the tones containing the TR signal are changing based on gNB’s decision, the UE receiver must be notified of the sub-carriers carrying the TR signal, and to rate match the data signal around the tones throughput all the symbols. The granularity of the tones is SCs (or several adjacent SCs) and can have several occurrences in frequency.
  + Potential specification impacts are:
    - Introducing messaging to inform the UEs of the SCs carrying the TR signal, to be rate matched by the receiver (e.g., in DCI)
    - Introducing enhancements on existing rate-matching patterns (e.g., PRB-symbol bitmaps, CSI-RS)
    - Signaling for providing tone reservation information to UE
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - Legacy UEs are not aware of the new rate matching patterns. It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

##### Technique #D-4: PA Input Power Bias ("input backoff”) Adaptation

* + Potential specification impacts are:
    - Eventual UE measurement configurations assessing the impact from BS PA backoff adaptation
    - BS unwanted in-band and out-of-band emissions exchange to neighbor BSs
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - BS PA backoff adaptation should not be applied when SSB/SI is transmitted in the cell and in neighbor cells so as UEs in idle/inactive mode are not affected.
    - BS PA backoff adaptation in legacy UEs has to be investigated. Eventually the scheme is not applied in the presence of legacy UEs.

##### Technique #D-5: UE post-distortion

* + UE digital post-distorsion (DPoD)
    - Overview: Digital Post distortion (DPoD) is non-linear processing on the receiver side. The receiver might implement variety of techniques with various complexity and performance tradeoffs. For example, the UE might implement a post channel equalization non-linear equalization stage that will “invert” the non-linearity introduced by the power amplifier.
    - Specification impact: The DPoD requires knowledge of the power amplifier model that can be obtained by signaling from the gNb to the UE
  + Potential specification impacts are:
    - High level configuration (e.g., UEs capability, list of power amplifier models)
    - Introduction of activation of UE post distortion and notification of selected power amplifier model, and possibly training reference signals.
    - Signaling for reporting assistance information for gNB digital pre-distortion, and indication to the UE of whether it needs to apply non-linear equalization for a transmission
  + Additional considerations/aspects (including any impact to legacy UEs, if any):
    - It is the gNB’s task to split transmissions to legacy and enhanced UEs in accordance with transmitted signal quality

# Agreements/Conclusions from RAN1 #110-bis-e

[TBD]

# Reference

1. R1-2208382, “Potential enhancements for network energy saving,” FUTUREWEI
2. R1-2208425, “Discussion on network energy saving techniques,” Huawei, HiSilicon
3. R1-2208519, “Network energy saving techniques,” Nokia, Nokia Shanghai Bell
4. R1-2208562, “Discussion on network energy saving techniques,” Spreadtrum Communications
5. R1-2208655, “Discussion on NW energy saving technique,” vivo
6. R1-2208777, “Discussion on potential network energy saving techniques,” China Telecom
7. R1-2208833, “Discussion on network energy saving techniques,” OPPO
8. R1-2208988, “Network Energy Saving techniques in time, frequency, and spatial domain,” CATT
9. R1-2209023, “Discussion on network energy saving techniques,” Fujitsu
10. R1-2209064, “Discussion on Network Energy Saving Techniques,” Intel Corporation
11. R1-2209127, “Network energy saving techniques,” Lenovo
12. R1-2209196, “Discussion on NW energy saving techniques,” ZTE, Sanechips
13. R1-2209296, “Discussions on techniques for network energy saving,” xiaomi
14. R1-2209349, “Discussion on network energy saving techniques,” CMCC
15. R1-2209425, “Discussion on network energy saving techniques,” NEC
16. R1-2209453, “Discussion on physical layer techniques for network energy savings,” LG Electronics
17. R1-2209501, “On network energy savings techniques,” MediaTek Inc.
18. R1-2209592, “Discussion on network energy saving techniques,” Apple
19. R1-2209612, “On Network Energy Saving Techniques,” Fraunhofer IIS, Fraunhofer HHI
20. R1-2209618, “Discussion on network energy saving techniques,” Rakuten Symphony
21. R1-2209633, “Discussion on potential network energy saving techniques,” Panasonic
22. R1-2209655, “Potential techniques for network energy saving,” InterDigital, Inc.
23. R1-2209743, “Network energy saving techniques,” Samsung
24. R1-2209859, “Network energy savings techniques,” Ericsson
25. R1-2209914, “Discussion on NW energy saving techniques,” NTT DOCOMO, INC.
26. R1-2209997, “Network energy saving techniques,” Qualcomm Incorporated
27. R1-2210031, “Discussion on potential L1 network energy saving techniques for NR,” ITRI
28. R1-2210113, “Discussion on Network energy saving techniques,” CEWiT