3GPP TSG-RAN WG1#118bis R1-24abcde

Heifei, China, Oct 14th-18th 2024

Agenda Item: 9.5.3

Source: Moderator (Ericsson)

Title: Summary of AI 9.5.3 for R19 NES

Document for: Discussion

# Introduction

This is the summary for AI 9.5.3 on the adaptation of common signalling for NES based on the views expressed by companies in the contributions listed in the Appendix A and providing topics and proposals for discussion/agreement.

# Adaptation of SSB in time domain

Topic 2.1.1

For the adaptation mechanisms of SSB in time-domain, several companies discussed which of the scenarios to support:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Yes | No |
| Rel-19 NES-capable UE’s PCell (Connected mode) | A2  adaptation for SSB that is not CD-SSB | Xiaomi, Ericsson, Honor, ZTE, CATT, Tejas, ETRI, Interdigital, Samsung, Huawei/HiSi, Sharp, Sony | LG, Apple, vivo, CMCC (if cell has CD-SSB with normal periodicity),  [Qualcomm (marginal NES gains)?],  SPRD (use TRS instead) |
| Rel-19 NES-capable UE’s PCell (Connected mode) | A3  adaptation for SSB not on sync raster | Xiaomi, Ericsson, Honor, ZTE, CATT, Tejas, ETRI, Interdigital, Samsung, Mediatek, Huawei/HiSi, Sharp, Sony | LG, Apple, vivo,  CMCC (if cell has CD-SSB with normal periodicity),  [Qualcomm (marginal NES gains)?],  SPRD (use TRS instead) |
| Rel-19 NES-capable UE’s SCell | B1  adaptation for CD-SSB | Nokia, [Xiaomi?], Ericsson (not on sync raster), FW, Honor, ZTE, DoCoMo, ETRI, Huawei/HiSi (not on sync raster), Cewit/CT/Sony (for CD-SSB>20ms periodicity), Sharp | LG, Qualcomm, Tejas, vivo, Mediatek  Apple/Interdigital(for CD-SSB>20ms periodicity), Transsion (on sync raster) |
| Rel-19 NES-capable UE in idle/inactive mode |  | Xiaomi, DoCoMo, NEC, [Tejas?], ETRI, SPRD, Sony  Ericsson (at least for cell not providing initial cell selection),  ZTE (cell with only Rel-19 UEs), | LG, Apple, Qualcomm, vivo, Mediatek, Transsion |

Potential points to consider:

* Legacy UE impact when CD-SSB is adapted on the SCell
  + Handling: barring, another freq layer with normal periodicity CD-SSB, etc?
* One main contributor for increased gNB energy consumption is the default 20ms SSB assumption for initial access by legacy UEs
  + If CD-SSB with normal (e.g. 20ms) periodicity is transmitted, no/minimal NES gains when adapting only SSB that is not CD-SSB
* Impact to Rel-19 NES capable UEs in idle/inactive mode
  + Handling: cell accessible only via cell reselection?
* [Nokia] From a connected UE perspective, it does not matter if the adapted SSB is CD-SSB or NCD-SSB because the UE does not need to decode the SIB1 in SCell.

## Discussion point 2.1.1

For Rel-19 NES-capable UE in idle/inactive mode, companies are encouraged to provide their views on the following scenarios from the proponents.

* Scenario 1: Adaptation of CD-SSB in the scenario that cell has only Rel-19 NES-capable UEs.
* Scenario 2: Adaptation of SSB for the scenario where the cell does not provide initial cell selection based on the following:
  + Adaptation for SSB that is not CD-SSB
  + Adaptation for SSB not on sync raster
  + Note: A sparse CD-SSB is present in the cell along with the adaptable SSB that is not CD-SSB.

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

## Discussion point 2.1.2

Companies are encouraged to provide their comments on whether/how to support adaptation of SSB in time domain for Rel-19 NES-capable UE’s PCell for the following cases:

* Adaptation for SSB that is not CD-SSB is supported (A2)
* Adaptation for SSB not on sync raster is supported (A3)

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

## Discussion point 2.1.3

Companies are encouraged to provide their comments on whether/how to support adaptation of SSB in time domain for Rel-19 NES-capable UE’s SCell for the following case:

* Adaptation for CD-SSB (B1)

|  |  |
| --- | --- |
| Company | Comment |
|  |  |

Several companies provided their views on extending Cell DTX to SSB adaptation.

* Option 1 (One SSB burst periodicity is configured for the UE and UEs assumes SSB transmissions are not present during Cell DTX non-active period)
  + CATT, Samsung, CT
* Option 2 (UE assumes SSB transmission with different periodicities during Cell DTX non-active period and during Cell DTX active period)
  + LG, FW, NEC, Oppo
* Option 3 (Cell DTX does not impact UE assumption on SSB transmissions (i.e. legacy behavior) – no spec impact)
  + Fujitsu, Apple, Interdigital, vivo, Huawei, Google, Ericsson, Mediatek, Honor, [Xiaomi?],[Nokia?], [DoCoMo?]

## Proposal 2.1.4

For Cell DTX extension to SSBs not on sync-raster for connected mode UEs, select Option 3, i.e. Cell DTX does not impact UE assumption on SSB transmissions (i.e. legacy behavior).

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comment |
|  |  |  |

# Adaptation of PRACH

Several companies provided their views on the adaptation mechanisms for the PRACH in time-domain, including configuration aspects, SSB-RO mapping, adaptation mechanisms.

* Alt 1 only (i.e. Same PRACH configuration index between legacy and additional PRACH resources)
  + Qualcomm, DoCoMo
* Alt 2 only (i.e. Different PRACH configuration index between legacy and additional PRACH resources)
  + FW, Apple, NEC, Panasonic, ZTE, Honor, Tejas, Interdigital, Oppo
* Both Alt 1 and Alt 2 (Same or different PRACH configuration between legacy and additional PRACH resources)
  + Nokia, LG, Huawei/HiSi, Samsung, Ericsson, Mediatek, vivo, Xiaomi, Fujitsu, CATT, CMCC, Google, CT

## Proposal 3.1.1

For adaptation of PRACH in time-domain, support both of the following

* Alt 1: The PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index for the legacy resources
* Alt 2: The PRACH configuration index for the additional PRACH resources is different from the PRACH configuration index for the legacy resources
* FFS: Additional details

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comment |
| Nokia/NSB | Y | None |

Additional frequency domain parameters

Several companies discussed supporting configuration of additional frequency domain parameters, such as frequency offset and frequency starting point.

* Support configuration of additional frequency domain parameters.
  + Vivo, LGE, Fujitsu, Nokia, CATT, Huawei/HiSi
* No need for additional frequency domain parameters. The legacy frequency offset parameter , can be configured independently for legacy and additional PRACH resources.
  + Tejas

## Proposal 3.1.2

For adaptation of PRACH in time-domain, frequency domain parameters can be configured separately for the additional PRACH resources.

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comment |
| Nokia/NSB | N | We would prefer to have a more step-by-step approach here. Which frequency domain parameters are we considering here? For instance, if we support the configuration of more than 1 , i.e., one for legacy and one for additional RO resources, this can have an impact on the overall spectrum occupancy of ROs, significantly reducing spectral efficiency as well. This will trivially impact other network operations, e.g., scheduling of other UL channels/signals, which may prevent gNB from entering any meaningful sleeping mode. This is also one of the reasons why typical implementations minimize the bandwidth footprint of ROs on the field. Could FL list the “frequency domain parameters” we are considering in this proposal and check whether companies are OK with all of them, please? |

Preamble format

Some companies mentioned that the preamble format should be the same for legacy and additional PRACH resources.

* + Nokia, Apple, Transsion

## Proposal 3.1.3

For adaptation of PRACH in time-domain, the same PRACH preamble format is used for the additional RACH resources and legacy PRACH resources.

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comment |
| Nokia/NSB | Y | None |

Several companies provided inputs on the DCI formats and RNTIs for carrying the adaptation indication, for connected and idle modes,

* DCI format 1\_0
  + Nokia, Huawei/HiSi, Qualcomm, Apple, Mediatek, DoCoMo, Xiaomi, CT, Fujitsu, Ericsson, CMCC, ZTE, CATT, Panasonic, vivo, Sony, Lenovo, Interdigital, Google
    - P-RNTI
      * Nokia, Xiaomi, Ericsson, Fujitsu, Apple, CATT, DoCoMo, Interdigital. Lenovo
    - SI-RNTI
      * Xiaomi, Ericsson, Fujitsu, CMCC
    - RA-RNTI
      * Xiaomi
    - C-RNTI
      * Lenovo/Google/Apple (for connected mode)
    - New RNTI
      * Fujitsu, Interdigital, ZTE, Tejas, ETRI, Sony
* DCI format 2\_7
  + Huawei/HiSi, Qualcomm, CMCC, ZTE, Panasonic, vivo, Oppo, Interdigital
  + No: DoCoMo
* DCI format 2\_9
  + FW, ZTE/vivo/Oppo (for connected mode), Sony, CT (if enhanced cell DRX for PRACH is supported),
  + No: DoCoMo

## Proposal 3.1.4

For DCI-based adaptation for additional PRACH resources, at least DCI format 1\_0 can carry the adaptation indication for UEs in idle/inactive and connected mode.

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comments |
| Nokia/NSB | Y | Support |

In last meeting, the following was agreed for the DCI-based adaptation for additional PRACH resources.

***Agreement***

*For DCI-based adaptation for additional PRACH resources, select only from the following alternatives*

* *Alt 1: (PRACH resource configuration level) DCI-based adaptation to indicate whether the additional PRACH resources provided by semi-static signalling are available or not*
  + *FFS: details*
* *Alt 2: (subset of PRACH resource level) DCI-based adaptation to indicate whether a subset of the additional PRACH resources provided by semi-static signalling are available or not*
  + *FFS: whether the subset of the additional PRACH resources is in* 
    - *Alt 2-1: RO level per SSB*
    - *Alt 2-2: SSB-to-RO mapping cycle level*
    - *Alt 2-3: PRACH association period level*
    - *Alt 2-4: PRACH association pattern period level*
    - *Alt 2-5: SFN level*
* *Alt 3: DCI-based Enhanced/new Cell DRX to indicate whether the enhanced/new Cell DRX is activated or deactivated.*
  + *If activated, the additional configured PRACH provided by semi-static signalling within non-active period are not available.*
  + *FFS: whether Alt 1 and/or Alt 2 can be applied to the active period*
  + *FFS: details*

Several companies provided their views on adaptation mechanism for PRACH in time domain.

* Alt 1 (PRACH resource configuration level)
  + Huawei/HiSi, FW, Mediatek, DoCoMo, vivo, Xiaomi, CATT, Ericsson, ZTE, Oppo
* Alt 2 (subset of PRACH resource level)
  + Nokia, Qualcomm, Apple, Samsung, DoCoMo, Xiaomi, Panasonic, CT, Fujitsu, Oppo, Cewit, Sony
* Alt 3: DCI-based Enhanced/new Cell DRX for PRACH
  + FW, Samsung, CT, NEC
  + No/deprioritize: Nokia, Apple, DoCoMo

## Discussion point 3.1.5

Given company inputs, FL suggestion is to focus further discussion on Alt 1 and Alt 2. Companies are requested to provide their comments on it.

|  |  |
| --- | --- |
| Company | Comments |
| Nokia/NSB | We fully support FL’s indication. We suggest focusing on these two alternatives, which are the ones supported by most companies, given:   1. The limited available time, 2. the fact that no company argues that Alt. 1 or Alt. 2 cannot work, 3. that 3 out of 4 companies supporting Alt 3 also have a second preference in Alt.1 or Alt. 2. |

# Adaptation of Paging

Many proposals submitted for this are related to the PO/PF determination and paging-related configuration/procedures defined in RAN2 specifications. As per the agreement in earlier RAN1 meeting, such aspects are expected to be handled by RAN2.

Regarding the adaptation, some companies discussed/proposed that using SI update mechanism is sufficient, while some others proposed to consider/support dynamic adaptation of paging. Few companies also suggested to wait for RAN2 progress.

## **Moderator suggestion for RAN1#118bis: continue to wait for RAN2 progress.**

# Other

Some contributions also discussed joint adaptation of more than one common signal/channel.

# Conclusion

# Appendix A (Contributions)

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | [**R1-2407621**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407621.zip) | Discussion of the adaptation of common signal/channel transmissions | FUTUREWEI |
| 2 | [**R1-2407687**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407687.zip) | On common channel/signal adaptation for eNES | Huawei, HiSilicon |
| 3 | [**R1-2407713**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407713.zip) | Discussion on adaptation of common signal/channel transmissions | Spreadtrum Communications |
| 4 | [**R1-2407740**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407740.zip) | Discussion on common signal/channel adaptation | China Telecom |
| 5 | [**R1-2407759**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407759.zip) | Adaptation of common signals/channels | Tejas Network Limited |
| 6 | [**R1-2407794**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407794.zip) | Adaptation of common signal/channel transmissions | Nokia, Nokia Shanghai Bell |
| 7 | [**R1-2407868**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407868.zip) | Discussions on adaptation of common signal/channel transmissions | vivo |
| 8 | [**R1-2407912**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407912.zip) | Discussion on adaptation of common signal/channel transmissions | CMCC |
| 9 | [**R1-2407976**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407976.zip) | Discussion on adaptation of common signal and channel transmissions | Xiaomi |
| 10 | [**R1-2407997**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2407997.zip) | Adaptation of Common Signals | Google |
| 11 | [**R1-2408054**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408054.zip) | Discussion on adaptation of common signal/channel transmissions | CATT |
| 12 | [**R1-2408073**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408073.zip) | Discussion on common signal channel for NES | ZTE Corporation, Sanechips |
| 13 | [**R1-2408123**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408123.zip) | Discussion on adaptive transmission of common signal or common channel | Transsion Holdings |
| 14 | [**R1-2408134**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408134.zip) | Discussion on adaptation of common signal/channel transmission | OPPO |
| 15 | [**R1-2408235**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408235.zip) | Discussion on adaptation of common signal channel transmissions | HONOR |
| 16 | [**R1-2408313**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408313.zip) | Discussion on adaptation of common signal/channel transmissions | InterDigital, Inc. |
| 17 | [**R1-2408352**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408352.zip) | Discussion on adaptation of common signal/channel transmission | Panasonic |
| 18 | [**R1-2408367**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408367.zip) | Adaptation of common signals and channels | Lenovo |
| 19 | [**R1-2408378**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408378.zip) | Discussion on adaptation of common signal/channel transmissions | NEC |
| 20 | [**R1-2408415**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408415.zip) | Adaptation of common signal/channel transmissions | Sony |
| 21 | [**R1-2408475**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408475.zip) | On adaptation of common signal/channel for NES enhancements+B19 | Apple |
| 22 | [**R1-2408501**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408501.zip) | Discussion on adaptation of common signal / channel transmissions | Fujitsu |
| 23 | [**R1-2408574**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408574.zip) | Adaptation of common signal/channel transmissions | ETRI |
| 24 | [**R1-2408607**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408607.zip) | Discussion on adaptation of common signal/channel transmissions | Sharp |
| 25 | [**R1-2408653**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408653.zip) | Adaptation of common signal/channel transmissions | Samsung |
| 26 | [**R1-2408678**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408678.zip) | Adaptation of common signal/channel transmissions | LG Electronics |
| 27 | [**R1-2408708**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408708.zip) | Adaptation of common signal/channel transmissions | MediaTek Inc. |
| 28 | [**R1-2408793**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408793.zip) | Discussion on adaptation of common signal/channel transmissions | NTT DOCOMO, INC. |
| 29 | [**R1-2408819**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408819.zip) | Adaptation of common signal/channel transmissions for NES | Ericsson |
| 30 | [**R1-2408857**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408857.zip) | Adaptation of common channel transmissions | Qualcomm Incorporated |
| 31 | [**R1-2408936**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408936.zip) | Discussion on adaptation of common signal and channel transmissions | CEWiT |
| 32 | [**R1-2408950**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_118b/Docs/R1-2408950.zip) | Adaptation of Common Signals and Channels for NES | Fraunhofer IIS, Fraunhofer HHI |

# Appendix B (WI objectives from WID in [RP-242354](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_105/Docs/RP-242354.zip))



# List of RAN1 agreements

## RAN1#116

**Agreement**

For adaptation of SSB in time-domain, consider the following adaptation mechanisms for further study

* Adaptation of SSB burst periodicity
* Adaptation based on two SSB configurations where up to two configurations can be active
* Adaptation based on skipping/transmitting some SSB bursts non-uniformly with single SSB configuration
* Adapting the transmitted number of SSBs within a SSB burst
* Cell DTX for SSB adaptation
* Whether to support new SSB burst periodicity value(s)
* Whether to support new SSB burst(s) (i.e. how SSB transmission is made within a burst)
  + New compact SSB burst(s)
  + Adapting the position of SSBs within a SSB burst
* Other mechanisms/combinations are not precluded

**Agreement**

For adaptation of PRACH in time-domain, consider the following adaptation mechanisms for further study

* Adaptation based on configuration of additional[/different] PRACH resources for NES-capable UEs in addition to PRACH resources for legacy UEs (if any)
  + Note: NES-capable UEs can use both additional PRACH resources and PRACH resources for legacy UEs
* For the additional PRACH resources,
  + Adaptation of PRACH resource periodicity/PRACH occasion
  + Adaptation at PRACH configuration/association period/association pattern period level and SSB to RO mapping cycle
  + Adaptation based on extending cell DRX operation for PRACH
  + Concentrating ROs in time domain
* Other options are not precluded

**Agreement**

For adaptation of paging,

* Study further from RAN1 perspective, techniques for adaptation of paging occasions in time-domain and achievable network energy savings
* Note: Specification details for PO/PF determination and paging-related configuration/procedures to be handled by RAN2

**Agreement**

For the adaptation mechanisms of SSB in time-domain, study further applicable scenarios and associated legacy UE impact/handling (if any) based on the following:

* Applicability to UE in idle/inactive and/or connected mode
* Applicability to PCell and/or SCell(s)

**Agreement**

For the adaptation mechanisms of SSB in time-domain, study further following mechanisms:

* Adaptation mechanism indicated or configured by gNB without UE trigger
* Adaptation triggered by UE (if any)

FFS: Details of associated signaling/indication/configuration

**Agreement**

For the adaptation mechanisms of PRACH in time-domain

* Support at least PRACH adaptation provided by gNB without UE trigger
  + FFS: PRACH adaptation with UE trigger
  + Note: UE trigger means UE requests adaptation of PRACH
* Study at least the following,
  + Dynamic signaling and/or semi-static signaling of PRACH adaptation
  + Adaptation of PRACH transmission according to certain condition
  + Applicability to idle/inactive and/or connected mode UEs
  + Which scenarios the adaptation mechanism is applicable to (e.g. cell with both legacy and Rel-19 UE, cell with only Rel-19 UEs)

## RAN1#116bis

**Agreement**

For indication of adaptation of SSB in time-domain,

* Support at least SSB adaptation provided by gNB without UE trigger

**Agreement**

For adaptation of PRACH in time-domain, support at least the following:

* Adaptation based on additional PRACH resources for NES-capable UEs in addition to PRACH resources for legacy UEs (if any)
  + Note: NES-capable UEs can use both additional PRACH resources and PRACH resources for legacy UEs
  + Configuration of additional PRACH resources is provided by semi-static signalling
    - FFS: details including whether there is overlap of additional PRACH resources and PRACH resources for legacy UEs
  + FFS: adaptation mechanism for additional PRACH resources
  + Note: No change to the existing PRACH configuration tables in 38.211

**Agreement**

For adaptation of PRACH in time-domain, support the following:

* SSB-RO mapping for the additional PRACH resources is separate from the SSB-RO mapping of the PRACH resources for legacy UEs (if any)
  + FFS: whether/how to handle SSB-RO mapping if the additional PRACH resources overlap in both time and frequency with the PRACH resources for legacy UEs
  + Note: SSB-RO mapping of the PRACH resources for legacy UEs is not impacted if Rel-19 UE uses these PRACH resources
  + FFS: SSB-RO mapping for the additional PRACH resources

**Agreement**

Support adaptation mechanisms of PRACH in time-domain for following:

* UE in idle/inactive mode
* UE in connected mode

**Agreement**

Adaptation mechanism(s) of SSB in time-domain is supported at least for one of the following scenario(s):

* For cell with both legacy UEs and Rel-19 NES-capable UEs
  + Rel-19 NES-capable UE’s PCell (Connected mode)
    - Study from the following options:
      * Option A1: adaptation for CD-SSB
      * Option A2: adaptation for SSB that is not CD-SSB
      * Option A3: adaptation for SSB not on sync raster
  + Rel-19 NES-capable UE’s SCell
    - Study from the following options:
      * Option B1: adaptation for CD-SSB
      * Option B2: adaptation for SSB that is not CD-SSB
      * Option B3: adaptation for SSB not on sync raster
  + FFS: Rel-19 NES-capable UE in idle/inactive mode
* Note: Impact to idle/inactive UEs shall be minimized

Agreement

For adaptation of PRACH in spatial domain,

* Study possibility of scenarios with non-uniform distribution of UEs in different beams
  + - Note 6: Companies are encouraged to provide details on how they map UEs to different beams
* Study network energy savings gain achieved by non-uniform PRACH resource allocation across SSBs for scenarios with non-uniform distribution of UEs in different beams (if any),
  + - Assume the following framework for network energy evaluation in FR1 and companies to report at least the below settings used in the evaluation/simulation
      * 20ms SSB period
      * 30kHz SCS, DDDSU TDD pattern
      * Setting A: SIB1 period (20ms/40ms/160ms)
      * Setting B1: Cell load (Empty/low/medium)
      * Setting B2: Traffic model
      * Setting C: SIB1 PDSCH time domain resource index in 38.214 Table 5.1.2.1.1-2
      * Setting D: CORESET0/SSB multiplexing pattern including controlResourceSetZero (index) in 38.213 Table 13-6, and searchSpaceZero (index) in 38.213 Table 13-11
      * Setting E1: PRACH configurations
        + (legacy) PRACH resources according to the following PRACH configuration for all transmitted SSBs
      * Case A1-1: PRACH configuration #5 (20ms)
      * Case A1-2: PRACH configuration #17 (10ms)
      * Case A2-1: PRACH configuration #0 (160ms)
        + (time-domain PRACH adaptation) Additional and legacy PRACH resources yielding total PRACH resources that are according to one of the following PRACH configuration for all transmitted SSBs
      * Case B1: PRACH configuration #17 (10ms)
      * Case B2: PRACH configuration #0 (160ms)
      * Companies to report details of assumed time domain adaptation mechanism
        + (spatial-domain PRACH adaptation) Additional and legacy PRACH resources yielding total PRACH resources that are according to one of the following PRACH configuration
      * Case C1: PRACH configuration #17 (10ms)
      * Case C2: PRACH configuration #0 (160ms)
      * Companies to report details of assumed spatial domain adaptation mechanism, including details of non-uniform PRACH resource allocation across SSBs
      * Setting F: Cat 1/Cat 2 BS as defined in TR38.864
      * Setting G1: Number of SSB beams: 4,8 SSBs in a SSB burst with SSB pattern case C
      * Note 1: Baseline to compare is Case C1 vs Case B1/A1-1/A1-2, Case C2 vs Case B2/A2-1
      * Note 2: It is up to company to report the SSB-RO mapping ratio and FDMed RO number, etc
      * Note 3: Other PRACH configuration index with different PRACH format other than format 0 is not precluded
      * Note 4: Other SSB/SIB1/RACH periodicity/PRACH resource/configuration assumptions are not precluded (up to companies to report)
    - Other frameworks for network energy evaluation are not precluded, e.g. including for FR2

## RAN1#117

**Agreement**

For the study of adaptation of PRACH in spatial domain, following network energy savings gains were reported by sources based on the evaluation framework agreed in RAN1#116bis:

* Two sources showed following NES gain for TDD, CAT1 BS power model, case C1 vs A1-1, zero load [R1-2404409, R1-2405107]
  + -4% ~ -45%
* Seven sources showed following NES gain for TDD, CAT1 BS power model, case C1 vs B1/A1-2, zero load [R1-2404225, R1-2404185, R1-2404334, R1-2404123, R1-2404562, R1-2405107, R1-2405163]
  + 0% ~ 31%
  + Note: Five sources assumed that case B1 has same PRACH resources as case A1-2. Remaining two sources evaluated only A1-2.
  + Note: Three sources showed NES gains 0% ~ 10% [R1-2404225, R1-2404185, R1-2404334]
* One source showed following NES gain for TDD, CAT1 BS power model, case C1 vs B1, zero load [R1-2404464]
  + 1.0%~8.8%
  + Note: The evaluation results provide the extra NES gain of spatial domain PRACH adaptation compared to time domain PRACH adaptation, where spatial domain and time domain PRACH adaptations are based on dynamic switching between PRACH resources according to two PRACH configuration indexes.
* One source showed following NES gain for TDD, CAT1 BS power model, case C1 vs B1, zero load [R1-2404626]
  + -48.41%~0%
  + Note: For B1, it was assumed that periodicity of PRACH resources can be adapted. For C1, it was assumed that periodicity of PRACH resources is not adapted and some ROs within a periodicity can be deactivated.
* One source showed following NES gain for TDD, CAT1 BS power model, for case C1 vs A1-2, zero load [R1-2404626]
  + 4.59%~38.04%
  + Note: For C1, it was assumed that periodicity of PRACH resources is not adapted and some ROs within a periodicity can be deactivated.
* Four sources showed following NES gain for TDD, CAT2 BS power model, case C1 vs B1/A1-2, zero load [R1-2404562, R1-2404225, R1-2403943, R1-2404626]
  + 0% ~ 3.5%
  + Note: Three sources assumed that case B1 has same PRACH resources as case A1-2. One source evaluated only A1-2.
* One source showed following NES gain for TDD, CAT2 BS power model, case C1 vs B1, zero load [R1-2404464]
  + 0%~0.2%
  + Note: The evaluation results provide the extra NES gain of spatial domain PRACH adaptation compared to time domain PRACH adaptation, where spatial domain and time domain PRACH adaptations are based on dynamic switching between PRACH resources according to two PRACH configuration indexes
* One source showed following NES gain for TDD, CAT2 BS power model, case C1 vs B1, zero load [R1-2404626]
  + -1.19%~0%
  + Note: For B1, it was assumed that periodicity of PRACH resources can be adapted. For C1, it was assumed that periodicity of PRACH resources is not adapted and some ROs within a periodicity can be deactivated.
* Two sources showed following NES gain for TDD, CAT1 or CAT2 BS power model, case C2 vs B2, zero load [R1-2403943, R1-2405107]
  + Less than 0.2%
* One source showed following NES gain for TDD, CAT1 BS power model, (C1 vs A1-2 with changed PRACH format), PRACH format A, 10ms PRACH periodicity, different loads [R1-2403980]
  + 13.7%/8.7%/4.9%/2.6% for zero/low/light/medium cell load
* One source showed following NES gain for TDD, CAT1 BS power model, (C1 vs B1 with changed PRACH format), PRACH format A, 10ms PRACH periodicity, different loads [R1-2403980]
  + 8.03%/5.1%/3.06%/1.74% for zero/low/light/medium cell load
* One source showed following NES gain for TDD, C1 vs B1/A1-2, different loads [R1-2404562]
  + 16%/4.78% for light/medium cell load for CAT1 BS power model
  + 0.65%/0.29% for light/medium cell load for CAT2 BS power model
* One source showed following NES gain for TDD, C1 vs B1, different loads [R1-2404626]
  + -18.57%~0%/-2.52%~0% for low /medium cell load for CAT1 BS power model
  + -0.81%~0%/-0.42%~0% for low /medium cell load for CAT2 BS power model
  + Note: For B1, it was assumed that periodicity of PRACH resources can be adapted. For C1, it was assumed that periodicity of PRACH resources is not adapted and some ROs within a periodicity can be deactivated.
* One source showed following NES gain for TDD, C1 vs A1-2, different loads [R1-2404626]
  + 3.67%~19.88%/2.29%~5.22% for low /medium cell load for CAT1 BS power model
  + 0.67%~1.75%/0.39%~0.91% for low /medium cell load for CAT2 BS power model
  + Note: For C1, it was assumed that periodicity of PRACH resources is not adapted and some ROs within a periodicity can be deactivated.
* One source showed NES gain for FDD, C1 vs B1, zero load [R1-2404464]
  + 1.4%~7% for CAT1 BS power model
  + 0%~0.3% for CAT2 BS power model
  + Note: The evaluation results provide the extra NES gain of spatial domain PRACH adaptation compared to time domain PRACH adaptation, where spatial domain and time domain PRACH adaptations are based on dynamic switching between PRACH resources according to two PRACH configuration indexes
* One source showed NES gain for FR2, CAT1 BS power model, spatial domain adaptation of PRACH configuration index 75 vs a time domain adaptation of PRACH configuration index 75, zero load [R1-2405163]
  + 4%~7%
* Note 1: About possibility of scenarios with non-uniform distribution of UEs in different beams
  + Several companies indicated (and three companies showed data/analysis) that there can be scenarios with non-uniform distribution of UEs in different beams.
  + Several companies mentioned that for non-uniform UE distribution, it can be addressed by gNB implementation e.g. by adjusting SSB beamwidth, etc. Several companies also mentioned that it is not clear how gNB can predict the distribution of UEs in different beams, especially for Idle/Inactive UEs.
* Note 2: Most sources that showed the NES gains (if any) for adaptation of PRACH in spatial domain compared to A1-2/B1 observed that the gain would be due to reduction in the number of overall ROs in time domain in their evaluations. Most of these companies only accounted for ROs in time domain.
* Note 3: The evaluation results assumed the non-uniform distribution of UE is static during the evaluation time period.

**Conclusion**

There is no consensus in RAN1 on the support of PRACH adaptation in spatial domain

**Agreement**

For adaptation of PRACH in time-domain, support at least the following case(s)

* Case 1: no time-domain overlap between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs
* Case 2: time-domain overlap but no overlap in frequency domain between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs
* Case 3: additional PRACH resources for NES-capable UEs and legacy PRACH resources overlap neither in time nor frequency domains
* FFS: whether additional conditions are needed to support the above cases
* FFS: Additional case whether full/partial overlap in both time and frequency is allowed
* Above does not preclude discussion for the case where the configuration for additional PRACH resources contains legacy PRACH resources

**Agreement**

At least for the case where legacy ROs and additional ROs overlap in neither time nor frequency domain, for adaptation of PRACH in time-domain, the SSB-RO mapping rule for additional PRACH resources follows the legacy SSB-RO mapping rule.

* Mapping SS/PBCH block indexes to valid additional PRACH occasions provided by semi-static signalling follows the legacy mapping order for preamble/time resource/frequency/PRACH slot indexes.
  + Note: This mapping is not impacted by time domain PRACH adaptation
* Validation rules for the additional PRACH resources follow the legacy validation rules for PRACH resources configured for legacy UEs.

**Agreement**

For adaptation of SSB in time-domain, Option 1 is supported

* Option 1: Adaptation of SSB burst periodicity using one or more SSB burst periodicity value(s)
* Note: Using Option 2 to realize Option 1 is not precluded
  + Option 2: Adaptation based on two SSB configurations [where up to two configurations can be active]
    - FFS: details of the differences between the two SSB configurations, e.g. two different periodicities
* FFS: Details including applicable scenarios
* FFS: Support of Cell DTX for connected mode UEs for SSB

**Agreement**

For adaptation of PRACH in time-domain, the additional PRACH resources are configured based on at least:

* a PRACH configuration index
* FFS: whether the PRACH configuration index is same and/or different from the PRACH configuration index for the legacy PRACH resources

Study further the following

* When the PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index for the legacy resource,
  + Additional parameter(s) for determining the additional PRACH resources e.g.
    - Scaled/adjusted PRACH configuration period
    - Additional timing offset
    - Adjusting the parameters (e.g., (x, y) value and slot number) of the PRACH configuration
    - Muting/masking ROs
* When the PRACH configuration index for the additional PRACH resources is different from the PRACH configuration index for the legacy resource
  + Additional mechanisms (if any) for determining the additional PRACH resources e.g.
    - Muting/masking ROs (e.g. for the case when the PRACH configuration index for the additional PRACH resources contains legacy resources)
* Additional parameters to facilitate condensed/cluster RACH resources in time-domain (including whether needed)

**Agreement**

For the adaptation mechanism for additional PRACH resources, study further the following:

* Option 1: Higher layer signalling (with potential enhancements) based PRACH resource adaptation
* Option 2: L1-based adaptation to indicate whether the additional PRACH resources provided by semi-static signalling are available or not
  + FFS: details
  + Strive to re-use existing DCI format(s)
* Option 3: Adaptation of PRACH transmission according to predefined condition(s)
  + FFS: details
* Option 4-rev1: L1-based adaptation to indicate whether a subset of the additional PRACH resources provided by semi-static signalling are available or not
  + FFS: whether the subset of the additional PRACH resources is in RO level / SSB-to-RO mapping cycle level/PRACH association period level/PRACH association pattern period level for time-domain PRACH adaptation
  + Strive to re-use existing DCI format(s)
* Option 5: Enhanced cell DRX

## RAN1#118

**Agreement**

For adaptation of PRACH in time-domain, select at least one from the following alternatives for configuration of the additional PRACH resources

* Alt 1: The PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index for the legacy resources and
  + Discuss further additional mechanism(s) for determining the additional PRACH resources, e.g.
    - Opt 1-1: Scaled/adjusted PRACH configuration period
    - Opt 1-2: Adjusting the parameters (e.g., (x, y) value and slot number) of the PRACH configuration
    - Opt 1-3: Muting/masking ROs
    - Opt 1-4: additional timing offset(s)
* Alt 2: The PRACH configuration index for the additional PRACH resources is different from the PRACH configuration index for the legacy resources,
  + Discuss further additional mechanism(s) for determining the additional PRACH resources, e.g.
    - Opt 2-1: Muting/masking ROs (e.g. for the case when the PRACH configuration index for the additional PRACH resources contains legacy resources)
    - Opt 2-2: Additional timing offset(s)
* FFS: Additional parameters to facilitate condensed/cluster RACH resources in time-domain (including whether needed)
* FFS: Additional frequency domain parameter(s) (e.g., freq. starting offset)

**Agreement**

Extend the RAN1#117 agreement on SSB-RO mapping rule for additional PRACH resources to Case 1

* Case 1: no time-domain overlap between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs

***RAN1#117 Agreement***

*At least for the case where legacy ROs and additional ROs overlap in neither time nor frequency domain, for adaptation of PRACH in time-domain, the SSB-RO mapping rule for additional PRACH resources follows the legacy SSB-RO mapping rule.*

* *Mapping SS/PBCH block indexes to valid additional PRACH occasions provided by semi-static signalling follows the legacy mapping order for preamble/time resource/frequency/PRACH slot indexes.*
  + *Note: This mapping is not impacted by time domain PRACH adaptation*
* *Validation rules for the additional PRACH resources follow the legacy validation rules for PRACH resources configured for legacy UEs.*

**Agreement**

For SSB-RO mapping rule for additional PRACH resources for Case 2.

* Extend the RAN1#117 and RAN1#118 agreements on SSB-RO mapping

**Agreement**

For the adaptation mechanism for additional PRACH resources (for CONNECTED mode UE and IDLE/INACTIVE mode UE),

* At least DCI based adaptation is supported. No introduction of new DCI format.

**Agreement**

For adaptation mechanism(s) of SSB in time-domain,

* For Rel-19 NES-capable UE’s PCell (Connected mode), adaptation of CD-SSB on sync raster is not supported
  + FFS: Adaptation for SSB that is not CD-SSB is supported (A2)
  + FFS: Adaptation for SSB not on sync raster is supported (A3)
* For Rel-19 NES-capable UE’s SCell
  + Adaptation of SSB configured for the SCell is supported for the following cases
    - FFS: Adaptation for CD-SSB (B1) including UE impact compared to legacy operation where the SSB is configured with periodicity>20msec for SCell
    - Adaptation for SSB that is not CD-SSB on sync raster (B2’)
    - Adaptation for SSB that is not CD-SSB not on sync raster (B3’)

**Agreement**

For DCI-based adaptation for additional PRACH resources,

* Select from the following DCI format(s) to carry the adaptation indication.
  + DCI format 1\_0
  + DCI format 2\_7
  + DCI format 2\_9
* FFS: existing (P-RNTI, SI-RNTI, CellDTRX-RNTI, PEI-RNTI, C-RNTI) or new RNTI used for detecting the DCI format

**Agreement**

For Cell DTX extension to SSBs not on sync-raster for connected mode UEs, select from following options

* Option 1: One SSB burst periodicity is configured for the UE and UEs assumes SSB transmissions are not present during Cell DTX non-active period
* Option 2: UE assumes SSB transmission with different periodicities during Cell DTX non-active period and during Cell DTX active period
* Option 3: Cell DTX does not impact UE assumption on SSB transmissions (i.e. legacy behavior) – no spec impact

**Agreement**

For DCI-based adaptation for additional PRACH resources, select only from the following alternatives

* Alt 1: (PRACH resource configuration level) DCI-based adaptation to indicate whether the additional PRACH resources provided by semi-static signalling are available or not
  + FFS: details
* Alt 2: (subset of PRACH resource level) DCI-based adaptation to indicate whether a subset of the additional PRACH resources provided by semi-static signalling are available or not
  + FFS: whether the subset of the additional PRACH resources is in
    - Alt 2-1: RO level per SSB
    - Alt 2-2: SSB-to-RO mapping cycle level
    - Alt 2-3: PRACH association period level
    - Alt 2-4: PRACH association pattern period level
    - Alt 2-5: SFN level
* Alt 3: DCI-based Enhanced/new Cell DRX to indicate whether the enhanced/new Cell DRX is activated or deactivated.
  + If activated, the additional configured PRACH provided by semi-static signalling within non-active period are not available.
  + FFS: whether Alt 1 and/or Alt 2 can be applied to the active period
  + FFS: details