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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

Several companies provided their views on the adaptation mechanisms for the SSB in time-domain.

* Adaptation of SSB burst periodicity
  + Xiaomi, Fujitsu, Nokia, Apple, DCM,QC,CMCC, Ericsson, CATT, ZTE, Interdigital, Panasonic, Lenovo?, SPRD, Fraunhofer, Sharp, Transsion, Google, LG, Mediatek, Sony, ETRI, Honor, Tejas
* Adaptation based on two SSB configurations where up to two configurations can be active
  + Nokia, CMCC, Samsung?, Ericsson, CATT?, Huawei, NEC?, Honor, Lenovo?, Fraunhofer, Intel, Sharp, KT, LG, Tejas, FW?, Fujitsu,
* Adaptation based on skipping/transmitting some SSB bursts non-uniformly with single SSB configuration
  + Yes: ZTE, Tejas, Mediatek
  + No/deprioritize: Nokia, Apple, DCM
* Adapting the transmitted number of SSBs within a SSB burst
  + Yes: Xiaomi?,Fujitsu,QC, Interdigital, Oppo, Transsion, KT, Cewit, Panasonic (only continuous)
  + No: Nokia (no L1/L2)
* Cell DTX for SSB adaptation
  + Yes: FW, CMCC, Samsung, NEC, LG, Tejas,
  + No: Nokia, Ericsson, DCM?
* Whether to support new SSB burst periodicity value(s)
  + Yes, >160ms
    - Fujitsu, vivo, Transsion, Tejas
  + Yes, < 5ms
    - Huawei,
  + No: Nokia, Apple?, Ericsson, Panasonic (no larger than 160ms), SPRD?
* Whether to support new SSB burst(s) (i.e. how SSB transmission is made within a burst)
  + New compact SSB burst(s)
    - Yes: Huawei,
    - No: Xiaomi, Fujitsu? Nokia, Ericsson, Panasonic?, Honor,
  + Adapting the position of SSBs within a SSB burst
    - Yes: Oppo,
    - No: Nokia, Ericsson, Panasonic?, Honor?,

## Proposal 2.1.1

For adaptation of SSB in time-domain, at least one of the following adaptation mechanisms is supported.

* Option 1: Adaptation of SSB burst periodicity using one or more SSB burst periodicity value(s)
* Option 2: Adaptation based on two SSB configurations where up to two configurations can be active
* FFS: details including applicable scenarios
* FFS: other adaptation mechanisms

## Topic 2.1.2

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) | A1  adaptation for CD-SSB | Xiaomi, Nokia (to no larger than 20ms), FW, Huawei, Interdigital, DCM, Panasonic, ZTE, CMCC?, CATT, Tejas, ETRI, Cewit, Sharp | LG, QC, vivo, Transsion, Mediatek?, Apple? |
| Rel-19 NES-capable UE’s PCell (Connected mode) | A2  adaptation for SSB that is not CD-SSB | Nokia?, FW, Ericsson (at least), Samsung, Fujitsu, Huawei, QC, Panasonic, CMCC?, CATT, Mediatek, Fraunhofer | LG, vivo |
| Rel-19 NES-capable UE’s PCell (Connected mode) | A3  adaptation for SSB not on sync raster | Huawei, QC, Panasonic, Mediatek, Transsion | FW, LG, vivo |
| Rel-19 NES-capable UE’s SCell | B1  adaptation for CD-SSB | Xiaomi, Nokia (to no larger than 20ms), FW, Huawei, Interdigital, DCM, Panasonic, ZTE, CMCC, CATT, Tejas, ETRI, Cewit, Sharp | LG, QC, vivo, Transsion, Mediatek?, Apple? |
| Rel-19 NES-capable UE’s SCell | B2  adaptation for SSB that is not CD-SSB | Xiaomi, Nokia, Ericsson (at least), LG, Samsung, Fujitsu, Huawei, QC, Panasonic, CMCC?, CATT, Mediatek, Fraunhofer | FW |
| Rel-19 NES-capable UE’s SCell | B3  adaptation for SSB not on sync raster | Xiaomi, LG, Apple, Huawei, QC, Panasonic, Mediatek, Transsion | FW |
| Rel-19 NES-capable UE in idle/inactive mode |  | Xiaomi, Ericsson (at least for non-initial access cell), Fujitsu, Huawei, CMCC, Interdigital,Intel DCM, ZTE, Panasonic, CATT?, Honor (prioritize), SPRD, Tejas?, ETRI, Fraunhofer, Sony, KT | QC, vivo, Apple, Mediatek, LG |

Potential points to consider:

* Legacy UE impact when CD-SSB is adapted
  + Handling: barring, 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?

## Proposal 2.1.2

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

* + Rel-19 NES-capable UE’s PCell (Connected mode)
    - Select 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
    - Select 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
  + Rel-19 NES-capable UE in idle/inactive mode
    - FFS: whether R19 NES-capable UE can use the cell for initial cell selection

# 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.

## Proposal 3.1.1

For adaptation of PRACH in time-domain, the SSB-RO mapping order for additional PRACH resources follows the legacy SSB-RO mapping order.

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comments |
| CATT | Y | The SSB-RO mapping order for additional PRACH resource can reuse the legacy SSB-RO mapping order. We don’t see the motivation or benefit to enhance the legacy SSB-RO mapping order. |
| Tejas Networks | Y | Supporting the above proposal |
| CMCC | Y | Do not observe a need to enhance the mapping order of SSB-RO for additional PRACH configuration. |
| Sharp |  | It’s not clear what the mapping order here means.  If it means SSB-to-RO mapping rule, it depends whether there is overlapping between additional PRACH resources and PRACH resources for legacy UEs. (i.e. whether support FFS part in Proposal 3.1.2.).  At least, we are fine with the proposal with no overlapping case. |
| HONOR | N | As analysed in our contribution, using a different mapping order from legacy can reduce access latency. |
| vivo |  | If SSB-RO mapping order in the proposal means the SSB-to-RO mapping rule in 38.213, we are supportive of the proposal.  We don’t see the need to define new mapping rule for the additional PRACH resources. |
| Spreadtrum | Y |  |
| DCM | Y |  |
| Panasonic | Y |  |
| LG Electronics | N | It depends on whether to allow overlapping between legacy PRACH resource and additional PRACH resource. |
| Futurewei | Y |  |
| ITRI | Y |  |
| ETRI |  | If the intention is only for the mapping “order”, the proposal seems fine. The whole mapping rule may or may not be changed depending on decision on PRACH spatial domain adaptation. |
| Apple |  | According to our understanding, the SSB-RO mapping rule including mapping order, valid RO determination should both be as legacy. |
| Intel |  | Similar understanding as LG it would be best to first discuss how to handle the overlap. We however agree that if there is no overlap legacy rules are sufficient. |
| ZTE, Sanechips | N | 1. We should discuss **Proposal 3.1.2** **firstly**, because whether or not additional PRACH resources are overlapped in both time and frequency domain may results into different results for SSB-RO mapping. 2. “SSB-RO mapping” in Proposal 3.1.1 is unclear to us. Does the SSB-RO mapping order mean the SSB index order, or refer to the time/frequency order?   As a result, we suggest following revisions:  For adaptation of PRACH in time-domain, the SSB-RO mapping rule ~~order~~ for additional PRACH resources follows the legacy SSB-RO mapping rule ~~order~~ |
| Qualcomm |  | Per our understanding, discussion of the proposal is related to the existing 38.213 text:  “SS/PBCH block indexes provided by ssb-PositionsInBurst in SIB1 or in ServingCellConfigCommon are mapped to  valid PRACH occasions in the following order where the parameters are described in [4, TS 38.211].  - First, in increasing order of preamble indexes within a single PRACH occasion  - Second, in increasing order of frequency resource indexes for frequency multiplexed PRACH occasions  - Third, in increasing order of time resource indexes for time multiplexed PRACH occasions within a PRACH slot  - Fourth, in increasing order of indexes for PRACH slots”  There are two related discussions:   1. How to define valid PRACH occasion? 2. Whether we following the order of mapping for preamble/frequency/time resources of the PRACH?   For both discussions, it is reasonable to follow the existing specs for SSB-RO mapping. Hence, we suggest adding more clarification to the proposal as follows:  ***For adaptation of PRACH in time-domain,***   * ***Validation rules for the additional PRACH resources follow the legacy validation rules for PRACH resources configured for legacy UEs.*** * ***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.*** |
| Moderator |  | Updated proposal below. |

## Proposal 3.1.1-updated

For adaptation of PRACH in time-domain, the SSB-RO mapping order for additional PRACH resources follows the legacy SSB-RO mapping order.

* [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.]
* [Validation rules for the additional PRACH resources follow the legacy validation rules for PRACH resources configured for legacy UEs.]

## Proposal 3.1.2

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

* no time-domain overlap between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs
* 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
* FFS: whether overlap in both time and frequency is supported

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comments |
| CATT | N | We firstly should discuss how to configure the addition PRACH resource, then identify whether there is overlapped RO issue using this method. Thus, it’s better to wait the progress of the discussion on Proposal 3.1.3. |
| Tejas Networks | N | There should not be any overlap between additional and legacy PRACH resources, neither in time nor in frequency domain. |
| Sharp | Y | We are fine with first two bullets.  We are OK to consider FFS part, and we assume it requires some new SSB-to-RO mapping rule to avoid impact to legacy UEs. |
| HONOR | Y | Resource configuration can overlap as long as it is transparent to legacy users. |
| vivo | N | We don’t think the explicit definition in the spec is needed for handling of overlapping cases between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs.  For RedCap or CovE, additional PRACH resources can be configured. There was similar discussion. It is up to gNB to handle the configuration of additional PRACH resources. Hence, the same method can be used. |
| Panasonic |  | We are okay with first two bullets. On the third one, we propose to change to “FFS: whether overlap in both time and frequency is allowed”, as this is not something to support for a purpose. |
| LG Electronics | Y | Generally fine with proposal and prefer to consider the case which the additional PRACH resources overlaps legacy PRACH resources in both time and frequency domains. |
| Futurewei | Y | We do not need the last bullet in our opinion if the first two are supported. |
| OPPO | Y | Why not make it simple by:  For adaptation of PRACH in time-domain, the additional PRACH resources are not overlapped in time and frequency domains with the PRACH resources for legacy UEs |
| ETRI | Y |  |
| Apple |  | Generally fine with the direction, as long as the valid RO determination is the same as legacy. |
| Intel | Y |  |
| ZTE, Sanechips | N | We support the first two bullets. But for the third bullet, in our view, the overlap in both time and frequency domain exist based on gNB’s configurations. For example, this case would be clearer with following clarification/modification:   * ~~FFS: whether overlap in both time and frequency is supported~~ * Both time and frequency overlap between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs   + NOTE: additional PRACH resources include the overlapped PRACH resources |
| Moderator |  | Updated proposal below. |

## Proposal 3.1.2-updated

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

* no time-domain overlap between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs
* 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
* no overlap between additional PRACH resources for NES-capable UEs and legacy PRACH resources in time and frequency domains
* FFS: whether overlap in both time and frequency is allowed

## Proposal 3.1.3

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

* a PRACH configuration index

Study further the need for following:

* 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]
* Whether the PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index of the legacy resources
* Additional parameters to facilitate condensed RACH resources in time-domain

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comments |
| CATT |  | If a PRACH configuration index for additional PRACH resource is supported, what’s the motivation to further study other methods? Do we need to introduce another method for additional PRACH resource configuration?  From our perspective, only one method listed above should be supported, which is sufficient for NR system. We suggest to modify as following:  For adaptation of PRACH in time-domain, the additional PRACH resources are configured based on at least:   * a PRACH configuration index   ~~Study further the need for following:~~   * ~~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]~~ * ~~Whether the PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index of the legacy resources~~ * ~~Additional parameters to facilitate condensed RACH resources in time-domain~~ |
| Tejas Network | Y | We suggest methods that avoid overlap of legacy and additional PRACH resources, for simpler SSB-RO mapping rule. Additional PRACH configuration index will create overlap of additional and legacy PRACH resources.  Hence, we make the following proposal,  For adaptation of PRACH in time-domain, the additional PRACH resources are configured based on at least:   * a PRACH configuration index chosen such a way that there should not be any overlap of additional and legacy PRACH resources. * Adjusting the parameters (e.g., (x, y) value and slot number) of the PRACH configuration. * Whether the PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index of the legacy resources * Combination of Adjusting parameters i.e., “x and y”, and PRACH configuration index. |
| CMCC | Y | We are open to discuss the specific scheme |
| Sharp | Y | The necessity of contents other than PRACH configuration index may depend on the support of FFS part in Proposal 3.1.2. If NW needs to avoid time domain collision between additional PRACH resources and PRACH resources for legacy UEs, it may be hard to achieve by only PRACH configuration index adaptation in some configuration case. |
| HONOR | Y | We are fine with the proposal. |
| vivo | Y |  |
| Spreadtrum | Y |  |
| DCM | Y |  |
| Panasonic |  | Okay in general. One question is what is the intention of the second last bullet for energy saving? |
| LG Electronics | Y | We prefer to configure the additional PRACH resource by using separate RACH configuration (i.e., a PRACH configuration index), or by adjusting the parameters (e.g., (x, y) value and slot number) of the default RACH configuration. |
| Futurewei | Y |  |
| ETRI | Y |  |
| Apple |  | We think there are two ways to avoid the overlapping:   1. A PRACH configuration index + additional offset to y or to the subframe/slot 2. No addition PRACH configuration index (reuse legacy PRACH configuration index) + scaled PRACH configuration period (adjusting x) + additional offset to y or to the subframe/slot   We are not very sure of the following bullet, if our understanding is correct, if the following indicates a same PRACH configuration index as the legacy resource, the PRACH configuration index for the additional PRACH resource is not needed.   * Whether the PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index of the legacy resources |
| Intel | Y |  |
| ZTE, Sanechips | Y | We are fine with the proposal. |
| Qualcomm |  | We think the modification from CATT is fine. However, we should have an FFS as follows (which is modification of one of the bullets in the FFS list):  ***FFS:*** ***Whether the PRACH configuration index for the additional PRACH resources is same or different from the PRACH configuration index configured for the legacy PRACH resources*** |
| Moderator |  | Updated proposal below. |

## Proposal 3.1.3-updated

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

* a PRACH configuration index

Study further the need for following:

* 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]
* Whether the PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index of the legacy resource with additional parameter(s) for determining the additional PRACH resources e.g. additional timing offset
* [Whether the PRACH configuration index for the additional PRACH resources is different from the PRACH configuration index configured for the legacy PRACH resources]
* Additional parameters to facilitate condensed RACH resources in time-domain

## Proposal 3.1.4

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

* Option 1: No adaptation mechanism, i.e. additional PRACH resources provided by semi-static signalling are always used
* 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 certain condition
  + FFS:details

|  |  |  |
| --- | --- | --- |
| Company | Support (Y/N) | Comments |
| CATT | Y | We prefer to support option 2 which can indicate adaptation dynamically. |
| Tejas Networks | Y | Support. |
| CMCC | Y | Support  Also, we prefer option 2 to decrease both latency and signalling cost upon the adaptation. |
| Sharp | Y | We prefer Option 2. |
| HONOR | Y | We are fine with the proposal. |
| vivo | Y | Option 1 is baseline. Option 2 can be additionally supported. |
| Spreadtrum | Y |  |
| DCM | Y | If option2 is not supported, the motivation of additional PRACH resource is quite unclear.  The legacy PRACH resources that can be semi-statically configured/updated already can offer flexible PRACH pattern according to the demand of NES and RACH capacity.  On top of that, the only thing that additional PRACH resources can/shall offer is that they can dynamically provided. |
| Panasonic | Y |  |
| LG Eletronics | Y | We prefer Option 2. |
| Futurewei | Y | We prefer Option 2. |
| ITRI | Y | We prefer Option 2. |
| ETRI | Y | We prefer Option 2. |
| Apple |  | For clarification, we are wondering whether option 2 only means that the dynamic signaling to use the additional PRACH resources or not, i.e. switching between the additional PRACH resource and legacy PRACH resource.  On one hand, for the cell that has only R19 NES UEs, there is no legacy PRACH resource and adaptations are needed on the additional PRACH resources.  On the other hand, in our previous agreement, there are further adaptations on the additional resources that needs to be considered.  We propose to add option 4 as follows:   * Option 4: L1-based adaptation to indicate adaptation of the additional PRACH resources provided by semi-static signalling by muting ROs   + FFS: whether the muting is in SSB-to-RO mapping cycle level/PRACH association period level/PRACH association pattern period level   + Strive to re-use existing DCI format(s)   **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 |
| Intel | Y | We think there are benefits for both option 1 and option 2. Option 3 is unclear to us as related signalling would anyhow need to be present. Thus we think Option 3 is covered by Option 1 and Option 2. |
| ZTE, Sanechips | Y | We support Option 2. |
| Qualcomm |  | We suggest modifying Option 1 to the following since if we go with this option, we still have adaptation but it is done in semi-static manner.   * ***Option 1: Additional PRACH resources provided by semi-static signalling are always used***   Furthermore, we suggest removing FFS under options since we may also need to enhance specs for more efficient adaptation with Option 1. |
| Moderator |  | Updated proposal below. |

## Proposal 3.1.4-updated

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

* Option 1: No additional adaptation mechanism, i.e. additional PRACH resources provided by semi-static signalling are always used
* 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 certain condition
  + FFS:details]
* Option 4: L1-based adaptation to indicate adaptation of the additional PRACH resources provided by semi-static signalling by muting ROs
  + FFS: whether the muting is in SSB-to-RO mapping cycle level/PRACH association period level/PRACH association pattern period level
  + Strive to re-use existing DCI format(s)

## Topic 3.2 Study of adaptation of PRACH in spatial domain

Several tdocs mentioned that distribution of UEs in different beams can be different/non-uniform [Nokia, Intel, Qualcomm, Samsung, DCM, Apple, Ericsson]. Three tdocs showed data/analysis that the number of UEs in coverage of different SSB indices may be different [Intel, Qualcomm, Ericsson]. Some tdocs raised the question that it is not clear how gNB can predict the distribution of UEs in different beams, especially for Idle/inactive UEs [Oppo, Huawei, FW]. It was mentioned that gNB may detect the load from some directions are lower than some others [Samsung].

Some tdocs suggested that the gains due to spatial domain adaptation may be smaller vs. adaptation of PRACH in time domain. It was also mentioned that the no NES gains are expected by reducing the number of SSBs mapped to ROs and the potential NES gains are expected from muting/reducing overall ROs.

It was mentioned that the standards impact may be large due to spatial domain adaptation. It was also mentioned that due to presence of legacy UEs non-uniform spatial domain adaptation cannot address the issue fully, and gains may be marginal if legacy UEs are considered in the dimensioning of the resources.

For the study of adaptation of PRACH is spatial domain, following evaluation results were provided:

* 12 sources (Nokia, Ericsson, Samsung, QC, Interdigital, Intel, vivo, ZTE, CMCC, CATT, Huawei,Xiaomi) provided NES gain results
* For TDD, CAT1 BS model (Nokia, Ericsson, Samsung, QC, Interdigital, Intel, vivo, ZTE, CMCC, CATT?) and zero load
  + The NES gain of case C1 vs A1-1 is as follows.
    - -4% to -45.6% [CATT]
    - -10% [Ericsson]
  + The NES gain of case C1 vs B1/A1-2 is as follows.
    - <1.25% [Nokia],
    - 0% to 5.87% [vivo]
    - 1.0%~8.8% [CMCC]
    - 5.8% ~ 9.95% [Interdigital]
    - 1.8%~ 24.5% [Samsung]
    - 15.03% to 20.23% [ZTE]
    - <= 24% [Ericsson]
    - 16%~31% [QC]
  + The NES gain of case C2 vs B2 is as follows.
    - <0.2% [Ericsson]
* For TDD, CAT2 BS model (Nokia, ZTE, CMCC, Huawei) and zero load
  + The NES gain of case C1 vs B1/A2-1 is as follows.
    - 0%~0.2% [CMCC]
    - 0.62% to 0.77% [ZTE]
    - <1.25% [Nokia]
    - 1.78%~3.45% [Huawei]
  + The NES gain of case C2 vs B2 is as follows.
    - 0.16% to 0.23% [Huawei]
* Some source also provided additional evaluations for the NES gain of spatial domain adaptation vs time domain adaptation.
  + For TDD,
    - For CAT1, PRACH format A, 20ms PRACH periodicity [Intel]
      * 13.7%/8.7%/4.9%/2.6% for zero/low/light/medium cell load
    - For CAT1, C1 vs B1/A1-2 for different loads [ZTE]
      * 16%/4.78% for light/medium cell load
    - For CAT2, C1 vs B1/A1-2 for different load [ZTE]
      * 0.65%/0.29% for light/medium cell load
  + For FDD,
    - For CAT1, 1.4%~7% [CMCC]
    - For CAT2, 0%~0.3% [CMCC]
  + For FR2,
    - For CAT1, 4%~7% [QC]
* Xiaomi provided several results, including with various loads, CAT1, CAT2 power models, including with time-domain adaptation of PRACH and spatial domain adaptation of PRACH.

## Possible observation 3.2.1

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

* For TDD, CAT1 BS power model, for case C1 vs A1-1, zero load
  + Two sources showed NES gain of -4% ~ -45% [CATT, Ericsson]
* For TDD, CAT1 BS power model, for case C1 vs B1/A1-2, zero load
  + Five sources showed NES gains 0% ~ 10% [Nokia, vivo, CMCC, Interdigital, Samsung]
  + Four sources showed NES gains 15% ~ 31% [Samsung, ZTE, Ericsson, QC]
* For TDD, CAT2 BS power model, for case C1 vs B1/A1-2, zero load
  + Four sources showed NES gains between 0% ~ 3.5% [CMCC, ZTE, Nokia, Huawei]
* For TDD, CAT1 and 2 BS power model, for case C2 vs B2, , zero load
  + Two sources showed NES gains are less than 0.2% [Huawei, Ericsson]
* Evaluation results for additional scenarios/assumptions
  + One source showed following NES gain for TDD, CAT1 BS power model, PRACH format A, 20ms PRACH periodicity for different loads [Intel]
    - 13.7%/8.7%/4.9%/2.6% for zero/low/light/medium cell load [Intel]
  + One source showed following NES gain for TDD, C1 vs B1/A1-2 for different loads [ZTE]
    - 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 NES gain for TDD, C1 vs B1/A1-2 for FDD, zero load [CMCC]
    - 1.4%~7% for CAT1 BS power model
    - 0%~0.3% for CAT2 BS power model
  + One source showed NES gain for TDD, CAT1 BS power model, C1 vs B1/A1-2 for FR2, zero load [QC]
    - 4%~7%
* Note: [Most/All] sources showed the NES gains for adaptation of PRACH in spatial domain would be due to reduction in the number of overall ROs in time domain

Views on whether the feature should be supported.

Yes: Ericsson, QC, Samsung, LG, Intel, DCM, Mavenir?, KT?, Cewit

No/deprioritise: Huawei, vivo, Honor, Oppo

Clarify: Xiaomi

## Possible observation 3.2.1-updated

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

* For TDD, CAT1 BS power model, for case C1 vs A1-1, zero load
  + Two sources showed NES gain of -4% ~ -45% [CATT, Ericsson]
* For TDD, CAT1 BS power model, for case C1 vs B1/A1-2, zero load
  + Five sources showed NES gains 0% ~ 10% [Nokia, vivo, CMCC, Interdigital, Samsung]
  + Four sources showed NES gains 15% ~ 31% [Samsung, ZTE, Ericsson, QC]
* For TDD, CAT1 BS power model, for case C1 vs B1 zero load
  + One source showed NES gains -48.41%~0% [Xiaomi]
* For TDD, CAT1 BS power model, for case C1 vs A1-2, zero load
  + One source showed NES gains 4.59%~38.04% [Xiaomi]
* For TDD, CAT2 BS power model, for case C1 vs B1/A1-2, zero load
  + Four sources showed NES gains between 0% ~ 3.5% [CMCC, ZTE, Nokia, Huawei]
* For TDD, CAT2 BS power model, for case C1 vs B1, zero load
  + One source showed NES gains -1.19%~0% [Xiaomi]
* For TDD, CAT2 BS power model, for case C1 vs A1-2, zero load
  + One source showed NES gains 0.88%~2.53% [Xiaomi]
* For TDD, CAT1 and 2 BS power model, for case C2 vs B2, zero load
  + Two sources showed NES gains are less than 0.2% [Huawei, Ericsson]
* One source showed following NES gain for TDD (C1 vs A1-2 with changed PRACH format), CAT1 BS power model, PRACH format A, 10ms PRACH periodicity for different loads [Intel]
  + 13.7%/8.7%/4.9%/2.6% for zero/low/light/medium cell load
* One source showed following NES gain for TDD (C1 vs B1 with changed PRACH format), CAT1 BS power model, PRACH format A, 10ms PRACH periodicity for different loads [Intel]
  + 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 for different loads [ZTE]
  + 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 for different loads [Xiaomi]
  + -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
* One source showed following NES gain for TDD, C1 vs A1-2 for different loads [Xiaomi]
  + 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
* One source showed NES gain for TDD, C1 vs B1 for FDD, zero load [CMCC]
  + 1.4%~7% for CAT1 BS power model
  + 0%~0.3% for CAT2 BS power model
* One source showed NES gain for TDD, CAT1 BS power model, Spatial domain adaptation of PRACH configuration index 75 vs a time domain adaptation PRACH configuration index 75, for FR2, zero load [QC]
  + 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 if non-uniform UE distribution is due to deployment, 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: For B1/A1-2, many sources that evaluated B1/A1-2 assumed case B1 has same PRACH resources as A1-2.
* Note 3: Most sources that showed the NES gains (if any) for adaptation of PRACH in spatial domain observed that the gain would be due to reduction in the number of overall ROs in time domain.
* Note 4: The evaluation results assumed the non-uniform distribution of UE is static during the evaluation time period.

## Possible Observation 3.2.1-updated2

An updated version is available in the drafts folder under ‘9.5.3/ ObservationForPRACHSD study’ for further checking.

## Proposal 3.2.2

For PRACH adaptation in spatial domain,

* Option 1
  + Support non-uniform PRACH resources per SSB for Rel19
    - FFS details of mechanism for non-uniform SSB to RO mapping
* Option 2
  + Additional mechanism for adaptation of PRACH in spatial domain is not supported
  + It is not precluded to discuss applicability of additional PRACH resources to subset of SSBs as part of time-domain PRACH adaptation mechanisms
* Option 3
  + Non-uniform PRACH resources per SSB is not supported for Rel19

# 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#117: wait for RAN2 progress.**

# Other

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

o Xiaomi, Fujitsu, CMCC, Ericsson, Samsung, CATT, Fraunhofer, Panasonic, ZTE.

# Appendix A (Contributions)

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | [**R1-2403871**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403871.zip) | Discussion of the adaptation of common signal/channel transmissions | FUTUREWEI |
| 2 | [**R1-2403895**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403895.zip) | Adaptation of common signal/channel transmissions | Tejas Networks Limited |
| 3 | [**R1-2403943**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403943.zip) | On common channel/signal adaptation for eNES | Huawei, HiSilicon |
| 4 | [**R1-2403980**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2403980.zip) | Adaptation of common signal/channel transmissions for Network Energy Saving | Intel Corporation |
| 5 | [**R1-2404034**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404034.zip) | Discussion on adaptation of common signal/channel transmissions | Spreadtrum Communications |
| 6 | [**R1-2404123**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404123.zip) | Adaptation of common signal/channel transmissions | Samsung |
| 7 | [**R1-2404185**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404185.zip) | Discussions on adaptation of common signal/channel transmissions | vivo |
| 8 | [**R1-2404225**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404225.zip) | Adaptation of common signal/channel transmissions | Nokia, Nokia Shanghai Bell |
| 9 | [**R1-2404295**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404295.zip) | On adaptation of common signal/channel for NES enhancements | Apple |
| 10 | [**R1-2404334**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404334.zip) | Discussion on adaptation of common signal/channel transmissions | InterDigital, Inc. |
| 11 | [**R1-2404409**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404409.zip) | Discussion on adaptation of common signal/channel transmissions | CATT |
| 12 | [**R1-2404464**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404464.zip) | Discussion on adaptation of common signal/channel transmissions | CMCC |
| 13 | [**R1-2404489**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404489.zip) | Adaptation of common signals and channels | Lenovo |
| 14 | [**R1-2404508**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404508.zip) | Adaptation of common signal/channel transmissions | Sony |
| 15 | [**R1-2404562**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404562.zip) | Discussion on common signal channel for NES | ZTE, Sanechips |
| 16 | [**R1-2404578**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404578.zip) | Discussion on adaptation of common signal channel transmissions | HONOR |
| 17 | [**R1-2404626**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404626.zip) | Discussion on adaptation of common signal and channel transmissions | Xiaomi |
| 18 | [**R1-2404691**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404691.zip) | Adaptation of Common Signals | Google |
| 19 | [**R1-2404759**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404759.zip) | Discussion on adaptation of common signal/channel transmission | Panasonic |
| 20 | [**R1-2404781**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404781.zip) | Adaptation of common signal/channel transmissions for NES | ETRI |
| 21 | [**R1-2404797**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404797.zip) | Discussion on adaptation of common signal/channel transmissions for Cell DTX/DRX | NEC |
| 22 | [**R1-2404809**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404809.zip) | Discussion on adaptation of common signal / channel transmissions | Fujitsu |
| 23 | [**R1-2404821**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404821.zip) | Discussion on adaptive transmission of common signal or common channel | Transsion Holdings |
| 24 | [**R1-2404860**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404860.zip) | Discussion on adaptation of common signal/channel transmission | OPPO |
| 25 | [**R1-2404896**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2404896.zip) | Adaptation of common signal/channel transmissions | LG Electronics |
| 26 | [**R1-2405050**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405050.zip) | Discussion on adaptation of common signal/channel transmissions | NTT DOCOMO, INC. |
| 27 | [**R1-2405072**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405072.zip) | Discussion on adaptation of common signal/channel transmissions | Sharp |
| 28 | [**R1-2405086**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405086.zip) | Adaptation of common signal/channel transmissions | MediaTek Inc. |
| 29 | [**R1-2405107**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405107.zip) | Adaptation of common signal/channel transmissions for NES | Ericsson |
| 30 | [**R1-2405128**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405128.zip) | Adaptation of Common Signal Channel Transmissions | Mavenir |
| 31 | [**R1-2405163**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405163.zip) | Adaptation of common channel transmissions | Qualcomm Incorporated |
| 32 | [**R1-2405179**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405179.zip) | Discussion on adaptation of common signal/channel transmissions | KT Corp. |
| 33 | [**R1-2405209**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405209.zip) | Adaptation of Common Signals and Channels for NES | Fraunhofer IIS, Fraunhofer HHI |
| 34 | [**R1-2405248**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_117/Docs/R1-2405248.zip) | Discussion on adaptation of common signal and channel transmissions | CEWiT |

# Appendix B (WI objectives from WID in [RP-240170](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_103/Docs/RP-240170.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