3GPP TSG RAN1#120 Meeting **R1-2500621**

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Source: **NEC**

Title: **Discussion on on-demand SSB for SCell operation**

Document for: **Discussion**

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1 Introduction

In RAN1#119, the following agreements were made [1]:

Agreement
Response to Q1 (What is the relation in terms of periodicity between always-on SSB and OD-SSB?) :

- The periodicity of on-demand SSB is one of 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms. RAN1 is discussing whether to introduce other periodicity value(s) for on-demand SSB.
- The periodicity of on-demand SSB can be configured separately from the periodicity of always-on SSB.
- RAN1 is discussing what is the relation between periodicity of always-on SSB and periodicity of on-demand SSB and it has been identified that the main use case is that the periodicity of on-demand SSB is equal to or smaller than that of always-on SSB.

Agreement
Response to Q3 (What is the relation in terms of frequency location between the always-on SSB and OD-SSB?):

- The frequency location of on-demand SSB is the same as the frequency location of always-on SSB at least for the case where always-on SSB is not CD-SSB. RAN1 is discussing the frequency location of OD-SSB for the case where always-on SSB is CD-SSB.

Agreement
Response to Q4 (What is the spatial relation between the always-on SSB and OD-SSB?) :

- SS/PBCH blocks with the same SSB indexes for always-on SSB and on-demand SSB are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and when applicable, spatial RX parameters.
  - Applies at least for the case when the centre frequency locations of always-on SSB and OD-SSB is same
- When a signal/channel is configured to be QCLed with a SSB index, the signal/channel is QCLed with the same SSB index of always-on SSB and on-demand SSB (if transmitted) with the same QCL parameters according to existing specifications
  - Applies at least for the case when the centre frequency locations of always-on SSB and OD-SSB is same
- At least the case where SSB indices within on-demand SSB burst are identical to SSB indices within always-on SSB burst is supported. RAN1 is discussing whether to support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

Agreement

- For a cell supporting on-demand SSB SCell operation, support to configure time domain location of on-demand SSB per on-demand SSB periodicity by RRC for both Case #1 and Case #2.

- For Case #1 (i.e., No always-on SSB on the cell),
  - Based on two parameters, where one is to indicate SFN offset from a reference point and the other is to indicate half frame index
    - The reference point is SFN which satisfies (SFN index *10) modulo (OD-SSB periodicity) = 0
    - If SFN offset parameter is NOT configured, UE assumes SFN offset set to 0.
    - If half frame index parameter is NOT configured, UE assumes half frame index set to 0.
    - The value range of SFN offset is 0 to 15 unless longer periodicity for on-demand SSB than 160 ms is introduced.
    - The value range of half frame index is 0 or 1.
- For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), down-select one of the following alternatives.
  - Alt A: Same as for Case #1
  - Alt B: Based on a single parameter which is to indicate the time offset between always-on SSB and on-demand SSB (e.g., similar to *ssb-TimeOffset*)

Agreement
New periodicity value for on-demand SSB other than the legacy values (i.e., 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms) is NOT introduced in Rel-19.

Agreement
Down-select at least one of the following alternatives.
- Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.
- Alt 2: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB
- Alt 3: Do not support the case where always-on SSB is CD-SSB on a synchronization raster.

Down-select at least one of the following alternatives:
- Alt A: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.
- Alt B: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB
- Alt C: Do not support the case where always-on SSB is CD-SSB and not on a synchronization raster.

Agreement
Response to Q2 (What is the relation in terms of time location between always-on SSB and OD-SSB?):
- RAN1 understands the time location of OD-SSB in Q2 refers to the time location of possible OD-SSB burst
- RAN1 is still discussing the relation in terms of time location between always-on SSB and OD-SSB

Agreement
For a cell supporting on-demand SSB SCell operation, support at least the following options to deactivate on-demand SSB transmission from a UE perspective.
- Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication
  - Deactivation by RRC is up to RAN2
  - FFS: Which scenario Option 1 is used

- Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
    - FFS: Whether Option 4, 4a is needed in addition to Option 2
    - FFS: Whether the value of N can be implicitly determined using a timer

In this contribution, we discuss our views on the remaining issues to support 'On-demand SSB for SCell operation'.

2 Discussion

2.1 On-demand SSB applicable scenarios

In RAN1#116b, the following agreement discusses the relevant scenarios for on-demand SSB [3]:

> *Agreement*
>
> *For the identified scenarios and cases (as per RAN1#116 agreement), on-demand SSB can be triggered by gNB at least for the following scenarios/cases:*
> - *Scenario #2 and Case #1*
> - *Scenario #2 and Case #2*
> - *Scenario #2A and Case #1*
> - *Scenario #2A and Case #2*
> - *FFS: Scenario #3A and Case #1*
> - *FFS: Scenario #3A and Case #2*
> - *FFS: Scenario #3B and Case #1*
> - *FFS: Scenario #3B and Case #2*
> - *For Case #1, once on-demand SSB is triggered, its transmission is in a periodic manner.*
>   - *Note: This does not imply periodic on-demand SSB is transmitted indefinitely after triggered.*

Scenario#2 as above considers the case where on-demand SSB indication is provided during the time duration between SCell configuration and the receipt of SCell activation command, while Scenario#2A considers the time instance when SCell activation command is received by the UE. Whether on-demand SSB indication can be provided to the UE after UE receives SCell activation command is covered by Scenario #3A (between SCell activation command reception and SCell being considered activated) and Scenario #3B (after SCell is considered activated).

Support of Scenario #3A requires further discussion due to its impact on UE SCell activation timeline as starting on-demand SSB after the transmission of SCell activation command can result in UE experiencing increased delay in activating the SCell. However, support of Scenario #3B can bring additional benefits for the UE as indicated below.

For Scenario #3B and Case #1, although on-demand SSB transmission will start on or before the SCell activation and is to be periodically transmitted, there may be cases where a UE may require transmission of more frequent SSBs than current on-demand SSB periodicity, e.g. beam failure recovery, especially if the gNB is in Cell DTX inactive duration, where regular SSB transmissions may not be available in order to achieve higher energy saving gain, SSB may be transmitted on demand.

For Scenario #3B and Case#2 (where both on-demand and always-on SSB are transmitted on SCell), the always-on SSB transmission is expected to have sparse periodicity, e.g. 80ms or 160ms, which allows UE to remain synchronized with the SCell. However, if there is a beam failure where SCell is deployed in FR2 and current SSB beam can no longer be used - either based on beam measurements or based on beam failure detection, relying only on always-on SSB could result in larger delay for the UE to acquire the correct SSB beam.

Observation 1: For Scenario #3B and Case#2, on-demand SSB transmission can improve the beam management performance for an activated SCell when the always-on SSB is transmitted with longer periodicity.

Furthermore, for Scenario #3B and Case #2 after SCell is activated, if RRM measurements are only handled by always-on SSB, the periodicity would need to be short enough so that it is not longer than the RRM measurement periodicity of all UEs. The energy saving gain may then be reduced compared to the case where both always-on SSB and flexible on-demand SSB are transmitted on the SCell.

Proposal 1: Support on-demand SSB operation for Scenario #3B Case #1 and Scenario #3B Case#2. Further discuss the applicability of Scenario#3A.

2.1.1 CD-SSB Aspects

The following agreements have been reached in RAN1#118 [3] and the case of CD-SSB being located on sync raster needs further discussion.

Agreement

For a cell supporting on-demand SSB SCell operation, at least the following is supported.

- *On-demand SSB on the cell is not located on synchronization raster.*
- *On-demand SSB on the cell is non-cell-defining SSB.*

FFS: Additional support of OD-SSB for CD-SSB located on sync-raster.

In this section we will discuss the applicability of on-demand SSB being CD-SSB on sync raster for both Case#1 and Case#2.

Before we begin the arguments discussion, it will be beneficial to look at the definition of CD-SSB.CD-SSB is defined in stage 2 as follows:

5.2.4 Synchronization signal and PBCH block

…

Within the frequency span of a carrier, multiple SSBs can be transmitted. The PCIs of SSBs transmitted in different frequency locations do not have to be unique, i.e. different SSBs in the frequency domain can have different PCIs. However, when an SSB is associated with an RMSI, the SSB corresponds to an individual cell, which has a unique NCGI (see clause 8.2). Such an SSB is referred to as a Cell-Defining SSB (CD-SSB). A PCell is always associated to a CD-SSB located on the synchronization raster.

...

8.2 Network Identities

…

- NR Cell Global Identifier (NCGI): used to identify NR cells globally. The NCGI is constructed from the PLMN identity the cell belongs to and the NR Cell Identity (NCI) of the cell. The PLMN ID included in the NCGI should be the first PLMN ID within the set of PLMN IDs associated to the NR Cell Identity in SIB1, following the order of broadcast.

...

According to this, CD-SSB is an SSB which is associated with RMSI for the cell. For the case of PCell, the CD-SSB is expected to be on synch-raster. If an SSB is not associated with RMSI, the SSB is not CD-SSB regardless of whether it is located on a synch-raster or not.

Further, for SSB transmitted, which is detected during cell search, it is specified in [4] how UE determines whether the SSB is associated with SIB1, i.e. whether the SSB is CD-SSB or not.

4.1 Cell search

…

Upon detection of a SS/PBCH block, the UE determines from MIB that a CORESET for Type0-PDCCH CSS set, as described in clause 13, is present if $k_{SSB} < 24$ [4, TS 38.211] for FR1 or if $k_{SSB} < 12$ for FR2. The UE determines from MIB that a CORESET for Type0-PDCCH CSS set is not present if $k_{SSB} > 23$ for FR1 or if $k_{SSB} > 11$ for FR2; the CORESET for Type0-PDCCH CSS set may be provided by PDCCH-ConfigCommon.

…

13 UE procedure for monitoring Type0-PDCCH CSS sets

If during cell search a UE determines from *MIB* that a CORESET for Type0-PDCCH CSS set is present, as described in Clause 4.1, the UE determines a number of consecutive resource blocks and a number of consecutive symbols for the CORESET of the Type0-PDCCH CSS set from *controlResourceSetZero* in *pdcch-ConfigSIB1*, as described in Tables 13-1 through 13-10, and determines PDCCH monitoring occasions from *searchSpaceZero* in *pdcch-ConfigSIB1*, included in *MIB*, as described in Tables 13-11 through 13-15.

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If a UE detects a first SS/PBCH block and determines that a CORESET for Type0-PDCCH CSS set is not present, and for $24 \le k_{\text{SSB}} \le 29$ for FR1 or for $12 \le k_{\text{SSB}} \le 13$ for FR2, the UE may determine the nearest (in the corresponding frequency direction) global synchronization channel number (GSCN) of a second SS/PBCH block having a CORESET for an associated Type0-PDCCH CSS set as $N_{\text{GSCN}}^{\text{Reference}} + N_{\text{GSCN}}^{\text{Offset}}$. $N_{\text{GSCN}}^{\text{Reference}}$ is the GSCN of the first SS/PBCH block and $N_{\text{GSCN}}^{\text{Offset}}$ is a GSCN offset provided by Table 13-16 for FR1 and Table 13-17 for FR2. If the UE detects the second SS/PBCH block and the second SS/PBCH block does not provide a CORESET for Type0-PDCCH CSS set, as described in Clause 4.1, the UE may ignore the information related to GSCN of SS/PBCH block locations for performing cell search.

If a UE detects a SS/PBCH block and determines that a CORESET for Type0-PDCCH CSS set is not present, and for $k_{\text{SSB}} = 31$ for FR1 or for $k_{\text{SSB}} = 15$ for FR2, the UE determines that there is no SS/PBCH block having an associated Type0-PDCCH CSS set within a GSCN range $[N_{\text{GSCN}}^{\text{Reference}} - N_{\text{GSCN}}^{\text{Start}}, N_{\text{GSCN}}^{\text{Reference}} + N_{\text{GSCN}}^{\text{End}}]$. $N_{\text{GSCN}}^{\text{Start}}$ and $N_{\text{GSCN}}^{\text{End}}$ are respectively determined by *controlResourceSetZero* and *searchSpaceZero* in *pdcch-ConfigSIB1*. If the GSCN range is $[N_{\text{GSCN}}^{\text{Reference}}, N_{\text{GSCN}}^{\text{Reference}}]$, the UE determines that there is no information for a second SS/PBCH block with a CORESET for an associated Type0-PDCCH CSS set on the detected SS/PBCH block.

If a UE does not detect any SS/PBCH block providing a CORESET for Type0-PDCCH CSS set, as described in Clause 4.1, within a time period determined by the UE, the UE may ignore the information related to GSCN of SS/PBCH locations in performing cell search.

…

RAN1 specification supports SSB indicating whether it is associated with RMSI, in other word whether it can be considered as CD-SSB. Note that for the case when SSB is not CD-SSB but on synch raster, the MIB indicates the next GSCN which may contain a CD SSB, which can optimise the UE cell search procedure.

Now we discuss the applicability of CD-SSB and location on synch raster for on-demand SSB. For case#1, following agreement was reached in RAN1#116bis:

- *For Case #1, once on-demand SSB is triggered, its transmission is in a periodic manner.*
    - *Note: This does not imply periodic on-demand SSB is transmitted indefinitely after triggered.*

According to the agreements, once the SCell is activated, on-demand SSB would be transmitted periodically when the UE is active on the SCell. In case that the SCell is being configured/activated for other UEs when on-demand SSB has been triggered and is transmitted periodically, the network does not need to trigger new on-demand SSB for the UEs. The network needs to transmit on-demand SSB periodically as long as at least one UE is active on the SCell. Indication of on-demand SSB transmission to NES UE during configuration/activation of the SCell when on-demand SSB has been triggered and is being transmitted periodically may or may not be needed.

Observation 2: For Case#1, gNB does not need to newly trigger on-demand SSB for a UE if the SCell is already active for another UE (FFS: indication).

Observation 3: For Case#1, on-demand SSB is not expected to be deactivated as long as at least one UE is active on the Cell even when the SCell is deactivated for a UE for which the network triggered the on-demand SSB.

As an SCell is a capacity cell, it is not expected that traffic is low when an SCell is configured/activated for one or multiple UEs. Otherwise, if traffic is low, the network can turn off the SCell to reduce network energy consumption. Therefore, on-demand SSB could keep transmitting periodically for a while until the traffic becomes low.

Observation 4: On-demand SSB would be transmitted periodically for a while as long as at least one UE is active on the cell, as SCell is a capacity cell and traffic on the capacity cell would not be low.

If on-demand SSB is transmitted periodically for a while on a NES SCell, the SCell can also be configured/activated for non-NES UE irrespective of whether the on-demand SSB is CD-SSB. When the network wants to stop on-demand SSB transmission on a NES SCell, the network may reconfigure UEs on the cell to remove the SCell.

Proposal 2: When on-demand SSB is transmitting periodically, NES cell can be used as an SCell for non-NES UEs irrespective of whether on-demand SSB is CD-SSB.

During the time period when on-demand SSB is transmitting periodically and if it is a CD-SSB, any kind of UE can detect the NES cell in cell search. The NES Cell can be used for initial access for any kind of UE in RRC_IDLE state at least for that duration. Any UE may camp on the NES cell. If the network wants to turn off the cell when traffic is getting low, it can move UEs camped on the cell to another coverage cell.

Proposal 3: At least for case#1, on-demand SSB can be CD-SSB and transmitted on synch-raster with assumption the network ensures periodic CD-SSB transmission when NES cell is activated for any UE.

2.1.2 Frequency Location of On-demand SSB for Case#2

In RAN1#119 [1], there was significant discussion about the frequency location of on-demand SSB for Case#2. It was agreed that frequency location of on-demand SSB shall be same as frequency location of always-on SSB at least for the case when always-on SSB is not CD-SSB. Further, following options were captures for further down selection for frequency location of on-demand SSB when always-on SSB is CD-SSB.

> *Agreement*
>
> *Down-select at least one of the following alternatives.*
>
> - *Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.*

- *Alt 2: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB*
- *Alt 3: Do not support the case where always-on SSB is CD-SSB on a synchronization raster.*

Down-select at least one of the following alternatives.

- *Alt A: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.*
- *Alt B: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB is the same as the frequency location of always-on SSB*
- *Alt C: Do not support the case where always-on SSB is CD-SSB and not on a synchronization raster.*

In Case #2, where a cell broadcasts an always-on SSB to provide the functionality of a CD-SSB, an on-demand SSB can be transmitted to provide supplementary benefits. The decision to utilize the same frequency for both always-on and on-demand SSB (when the always-on SSB provides a CORESET for Type0-PDCCH CSS set) hinges on whether the cell also accommodates legacy UEs.

Legacy UEs lack the capability to discern the on-demand transmission status of an SSB. Consequently, their behaviour becomes unpredictable if they encounter an on-demand SSB transmitted on the same frequency as the always-on SSB. In a worst-case scenario, legacy UEs might lose synchronization with the SCell if they persist in searching for an SSB during time intervals occupied by on-demand SSBs. This necessitates the support for a different frequency for on-demand SSB compared to the always-on SSB.

Observation 5: Legacy UEs, connected to an NES cell, may show unpredictable behaviour and potential synchronization loss if on-demand SSB share the same frequency as always-on SSBs.

This consideration becomes particularly critical when the always-on SSB is a CD-SSB deployed on a synchronization raster, as legacy UEs might utilize the cell for cell (re)selection. Conversely, if the always-on SSB is not on a synchronization raster, the network retains the discretion to either reserve that cell exclusively for NES users or to accommodate both NES and legacy UEs. Consequently, the network can choose to transmit the on-demand SSB on the same frequency or a different frequency as the always-on SSB.

Proposal 4: Support Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.

Proposal 5: Support Alt A: If always-on SSB provides a CORESET for Type0-PDCCH CSS set but is not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.

2.2 On-demand SSB Indication

2.2.1 DCI-based on-demand SSB indication

The following agreements have been reached in RAN1#117 [2]:

Agreement

- *For a cell supporting on-demand SSB SCell operation,*
  - *Support RRC based signaling to indicate on-demand SSB transmission on the cell.*
  - *Support MAC CE based signaling to indicate on-demand SSB transmission on the cell.*

- *FFS: Whether to support DCI based signaling to indicate on-demand SSB transmission on the cell.*
  - *This DCI signaling does not provide SCell activation/deactivation.*
  - *If supported, details on DCI including UE-specific or group-common DCI, DCI contents, etc.*
- *FFS: Scenarios where the above signaling are applicable*

The above agreement was reached considering the SCell activation requirements which can be performed by either RRC SCell configuration or using MAC CE activation command. However, when gNB needs to send the on-demand SSB indication to the UE for some other cases, e.g. between SCell configuration and SCell activation command, using RRC or MAC CE could result in high signaling overhead as this unicast indication would need to be sent to each UE individually.

Observation 6: Using MAC CE or RRC based indication for on-demand start indication is expected to increase signalling overhead when indication is sent for scenarios not involving SCell activation.

To indicate on-demand SSB transmission from gNB to UE for scenarios and use cases other than SCell activation, we support the introduction of group-common based DCI signaling. DCI signaling is also beneficial for L1 measurements based on-demand SSB, since RRC or MAC CE signaling indicating on-demand SSB for L1 measurements may result in longer delay. For example, after the completion of SCell activation (i.e. Scenario 3B), if on-demand SSB transmission on the cell has been activated to enable L1 measurement for one UE, dynamic indications via MAC CE to inform the enabling of on-demand SSB for other UEs may also be needed.

Proposal 6: Support on-demand SSB indication via group-common DCI for Scenario#2 and Scenario#3.

Note that for Case#1, enabling of on-demand SSB may be provided via PCell since the UE has a PCell connection. For Case#2, enabling of on-demand SSB can be provided either via PCell or the NES SCell as a UE may remain synchronized with SCell using always-on SSB. The details can be further discussed. For example, gNB may use DCI format 1_x on PCell with a carrier indication field to indicate the applicable carrier for the enabling of on-demand SSB transmission.

Proposal 7: On-demand SSB for SCell may be enabled via DCI format 1_x on PCell with a carrier indication field to indicate the applicable carrier.

2.2.2 On-demand SSB Transmission Timing

The following agreements have been reached in RAN1#119 [1]:

Agreement
For a cell supporting on-demand SSB SCell operation, support at least the following options to deactivate on-demand SSB transmission from a UE perspective.
- *Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication*
  - *Deactivation by RRC is up to RAN2*
  - *FFS: Which scenario Option 1 is used*
- *Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated*
  - *FFS: Whether Option 4, 4a is needed in addition to Option 2*
  - *FFS: Whether the value of N can be implicitly determined using a timer*

The following agreements have been reached in RAN1#118bis [1]:

Agreement

- *For a cell supporting on-demand SSB SCell operation, deactivation of on-demand SSB transmission is supported. In order to deactivate on-demand SSB transmission from a UE perspective, support at least one of the following options.*
    - *Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication*
    - *Option 1A: Explicit indication of deactivation for on-demand SSB via RRC for on-demand SSB transmission indication*
    - *Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated*
    - *Option 3: Configuration/indication of the duration of on-demand SSB transmission window*
    - *Option 4: On-demand SSB transmission, if any, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell*
    - *Option 4A: On-demand SSB transmission, if any, is deactivated when the timer for SCell deactivation is expired*
    - *Option 5: On-demand SSB transmission, if any, is deactivated when SCell activation is completed*
    - *Option 6: Explicit indication of deactivation for on-demand SSB via [group-common] DCI*
    - *FFS: Each option is applicable to which Cases or Scenarios*
    - *FFS: Details related to each of the above options*

For Case#1, while it can be assumed that on-demand SSB shall be transmitted continuously until SCell is activated for a UE, it cannot be assumed that SSB transmissions should be immediately stopped after SCell is deactivated for one UE as there might be another UE for which SCell may still be activated and due to which on-demand SSB transmissions are needed. However, from UE perspective we can specify that UE assumes SSB transmissions are stopped immediately upon SCell deactivation. If gNB needs UE to perform on-demand SSB measurements even after SCell deactivation (e.g. for RRM) then gNB may again indicate the start of on-demand SSB to the UE. For Case#1, UE assumes that SSB transmissions are stopped immediately after SCell deactivation. There is no need to define explicit deactivation signalling for on-demand SSB.

Proposal 8: Support Option 4 or Option 4A in addition: On-demand SSB transmission, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell or when the timer for SCell deactivation is expired.

For Case#2, as always-on SSB is already present, there is no need for on-demand SSB to be periodically transmitted after its trigger. In this case, on-demand SSB should only be transmitted for a few occasions which are required based on the use case.

The intermittent transmission of on-demand SSB transmission can be captured by either Option-1 or Option-2. Option-1 requires additional specification of a deactivation signalling for on-demand SSB. However, we do not think that there is a need for deactivation signalling as it increases the signalling overhead and may have the risk of non-synchronization between UE and gNB in relation to status of on-demand SSB transmission. Hence, our preference for Case#2 is to support Option-2.

Proposal 9: Support Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated.

As discussed above, we support Option 2. Considering one SCell may belong to multiple UEs, when the number of UE is large, it is not efficient to send deactivation MAC-CE for each UE. The number of OD-SSB bursts to fulfill different functionality may be different, so the indication of N could help UE know when it no longer needs to monitor OD-SSB. The value of N should be explicitly configured via RRC.

Proposal 10: Support explicit RRC configuration for the value of N.

Now we discuss the open points related to the RAN1#118bis agreement [2]:

> *Agreement*
> *The previous RAN1 agreement is partly confirmed and further revised as follows.*
> - *For SSB burst(s) indicated by on-demand SSB SCell operation via a MAC CE, UE expects that on-demand SSB ~~burst(s)~~ is transmitted from time instance A which is determined as follows.*
>   - *Alt 3-1: Time instance A is the beginning of the first slot containing ~~[candidate SSB index 0 or~~ the first actually transmitted SSB index~~]~~ ~~of~~within the first "possible" on-demand SSB burst which is at least T slots after the slot where UE receives a signalling from gNB to indicate on-demand SSB transmission*
>   - *The SSB time domain positions of on-demand SSB burst are configured by gNB.*
>   - *The location(s) (e.g., SFN offset, half frame index) in the time domain of "possible" on-demand SSB burst and SSB position within the burst should be configured by the gNB*
>   - *Note: The value of T is not less than existing timeline required for UE's MAC CE processing for SCell activation*
> - *Above applies at least for the case where SCell with on demand SSB transmission and cell with signalling transmission have the same numerology.*

The given RAN1 agreement was captured considering the case where SCell and PCell, where on-demand SSB indication is provided, have the same numerology. However, given that one of the primary use cases for supporting on-demand SSB is to support the case of inter-band CA where cells are expected to be operatingl with different numerology, we also need to support the scenario where cell providing the indication and cell where on-demand SSB is transmitted have different numerologies.

Proposal 11: RAN1 to discuss the case where SCell with on-demand SSB transmission and cell with on-demand SSB indication have different numerology.

In such a case, the value of T in the above agreement is automatically adjusted to account for the numerology used in the cell where UE receives the on-demand SSB start indication. However, its not clear whether SSB time domain positions are configured with respect to the timing/numerology of SCell or the cell where indication is received. Providing this configuration with respect to SCell timing/numerology may have its own set of challenges especially when we also consider the non-collocated SCell scenario where there might be time difference between PCell and SCell timing.

One possible mechanism to provide the SSB occasion configuration through PCell timings could be to reuse the *smtc* methodology which is already defined in the specification to indicate the potential occurrences of on-demand SSB transmissions. In NR, SMTC configuration can be indicated during SCell addition which allows UE to perform SSB detection. The smtc time reference is with respect to the PCell and contains the same periodicity value as *ssbperiodicityServingCell* indicated in *sCellConfigCommon*.

Observation 7: NR currently supports indication of smtc within SCellConfig during SCell addition which allows UE to optimise the SSB search. The smtc time reference is with respect to the PCell and contains the same periodicity value as ssbperiodicityServingCell indicated in sCellConfigCommon.

Here, SMTC configuration can be used to streamline the UE SCell SSB search operation. The SMTC configuration can be provided for on-demand SSB by gNB which shall indicate the potential locations where UE may search for on-demand SSB burst transmissions. The exact SMTC occasion from which on demand SSB shall be transmitted (after trigger) shall be indicated by the gNB to the UE so that UE may only start the SSB detection from the indicated SMTC occasions.

Proposal 12: For the case where SCell and the reference cell (where UE receives on-demand SSB indication) have different numerology, discuss further what time/numerology reference is used for the configuration of SSB time domain positions provided to the UE.

2.3 Multiplexing On-demand SSB and Always-on SSB

In Case#2, on-demand SSB may be transmitted in the same frequency as an always-on SSB (even if it is NCD SSB) or it can be transmitted on a different frequency from the always-on SSB. Collision handling can be needed in case that they are transmitted in the same frequency, e.g. where they fall in the same half frame and have different configuration for such as *ssb-PositionsInBurst*. Even if the on-demand SSB is due to be transmitted on frequency locations which are not used by always-on SSB, in case that the transmissions of always-on SSB and on-demand SSB are close in time, it is only necessary to transmit just one of them with a certain time frame for network energy saving purpose. For example, if gNB decides that always-on SSB is sufficient for UE request, gNB may drop the requested on-demand SSB transmission.

Always-on SSB may be given a higher priority than on-demand SSB initiated by the UE. If there is an always-on SSB transmission within a time window when an on-demand SSB transmission is due, UE is expected to monitor the always-on SSB.

In addition, the following method of handling for multiple UEs' on-demand SSB requests can be considered:

Allow only one configured SSB transmissions within a time window. The time window may be equal to legacy SSB periodicity. If there are more than one on-demand SSB transmissions due within the time window, gNB may transmit only one SSB transmission within the time window.

If there is already an on-demand SSB burst within the time window prior to a newly requested on-demand SSB, gNB may delay the newly requested on-demand SSB burst to the next time window. UE is expected to monitor the on-demand SSB for at least the duration of one time window. If there is an always-on SSB transmission or another newly requested on-demand SSB to be transmitted close by, the delayed on-demand SSB bursts may then be dropped.

Proposal 13: For Case#2, when on-demand SSB and always-on SSB overlap in time domain, consider always-on SSB is given higher priority than on-demand SCell SSB request.

Proposal 14: For Case#1 and Case#2, within a time window, combine multiple on-demand SSB transmissions due to multiple on-demand SSB requests into one in order to maximize network energy saving.

2.4 On-demand SSB transmission for RRM and other cases

RAN1 made an agreement in RAN1#118bis in relation to on-demand SSB support for L1 RRM requirements.

Agreement

- For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), consider only one or both of the following options for UE to perform L1 measurement based on on-demand SSB.
    - Option 1: A CSI report configuration is associated with both of on-demand SSB and always-on SSB
    - Option 2: A CSI report configuration is associated with one of always-on SSB and on-demand SSB
    - FFS: Whether OD-SSB and always on SSB have same beam or not

When a CSI report configuration is associated with only one of always-on SSB or on-demand SSB, there is more flexibility in the association between always-on SSB and on-demand SSB with less signalling

overhead. Furthermore, this also allows having different transmitted beams between on-demand SSB and always-on SSB. SCell activation is completed when the first valid CSI reporting is completed. In that sense, activation time can be shorter when CSI reporting is based on on-demand SSB assuming on-demand SSB has shorter periodicity than always-on SSB. With Option 2, it could be up to gNB implementation to select the associated SSB for the CSI reporting.

Proposal 15: Support Option 2: A CSI report configuration is associated with one of always-on SSB and on-demand SSB.

CSI reports in NR can contain measurement results associated to CSI-RS and/or SSB measurements, where the quantities relevant for SSB measurements are *ssb-index-RSRP* and *ssb-index-SINR*. Here, SSB based measurements are generally used for beam management. The occurrence of CSI reports can be classified as either periodic, *semiPersistentOnPUSCH*, *semiPersistentOnPUCCH* and aperiodic. When the report is of type periodic, then CSI configuration provides all the relevant parameters for report transmission. For the case of semi-persistent reporting, *semiPersistentOnPUSCH* are triggered using DCI while *semiPersistentOnPUCCH* reports are triggered using MAC CE. Aperiodic CSI report can be triggered by either DCI or MAC CE.

For on-demand SSB, as it is known that SSB transmission shall be periodic for Case#1, both periodic and semi-persistent CSI reports can be supported for on-demand SSB. For this case, on-demand SSB transmission indication can reuse the signalling methodologies considered earlier and no additional enhancement may be required other than specification support that the indication should be transmitted before the start of the corresponding CSI report transmissions.

Proposal 16: The on-demand SSB indication shall be provided to the UE before the start of the corresponding CSI report transmissions.

Several UE vendors have raised concerns about the difficulties UEs may face when simultaneously tracking both on-demand and always-on SSBs, particularly if the on-demand SSB transmissions are lengthy or recurring. This issue is relevant both before and after SCell activation.

Prior to SCell activation, SSBs primarily serve RRM measurement purposes. To address vendor concerns, we propose that UEs be directed to monitor either the on-demand or the always-on SSB, but not both simultaneously. Furthermore, the same SSB type should be used consistently for all periodic SSB measurements configured for the UE. This approach simplifies the UE's task and avoids potential conflicts arising from simultaneous monitoring of different SSB types.

Proposal 17: Before SCell activation, gNB to indicate one of on-demand SSB or always-on SSB for all configured periodic SSB measurements.

After SCell activation, the UE may be required to periodically monitor always-on SSB for link recovery procedures. In this case, on-demand SSB measurements can be supported but should only be triggered as aperiodic measurements so that a UE is not required to track both on-demand SSB and always-on SSB periodically.

Proposal 18: After SCell activation, only aperiodic on-demand SSB measurements are supported for NES SCell operation.

Further, for aperiodic on-demand SSB measurements, if we use the same signalling as being considered for SCell activation (i.e. MAC CE or RRC) then it will result in high signalling overhead as gNB would need to indicate start of on-demand SSB transmission to multiple UEs. Instead, to reduce the signalling overhead there are two options which can be considered:

- Support group-common based DCI indication; or
- Support indication of on-demand SSB within the CSI report trigger indication

Proposal 19: For aperiodic CSI reporting based on on-demand SSB consider one of the following options:

-Option-1: Support group-common based DCI indication for on-demand SSB indication
-Option-2: Support indication of on-demand SSB within the CSI report trigger indication

SSB transmission is also required for other scenarios which are not yet covered in the WID or current discussions. For instance, expiry of TAT for a SCell requires UE to initiate RACH, but RACH initiation itself requires UE to measure SSBs to determine the RACH resource. Hence, it is important to also consider that which other cases require on demand SSB transmission and how to enable on demand SSB for such cases.

Proposal 20: Discuss other cases (e.g. RACH initiation upon TAT expiry) for which on-demand SSB transmission may be required.

2.5 On-demand SSB failure handling

We also need to consider the UE behaviour when UE fails to receive on-demand SSB which may be initiated due to the mentioned use cases. Absence of any such specified procedure may result in unpredictable UE behaviour where a UE may request for on-demand SSB too frequently (if UE request for on-demand SSB is supported) or frequent connection failures. Hence, in this section we discuss the mechanisms which can be considered when UE fails to detect on demand SSB.

If the UE fails to receive/detect SCell SSB by the end of SSB monitoring period, e.g. within a monitoring time window, UE may indicate a failure to gNB for the SCell where on demand SSB reception has failed. On-demand SSB failure Indication may be sent via UCI or RRC. Alternatively, UE may re-request on-demand SSB for SCell when UE is not able to detect on-demand SSB as expected.

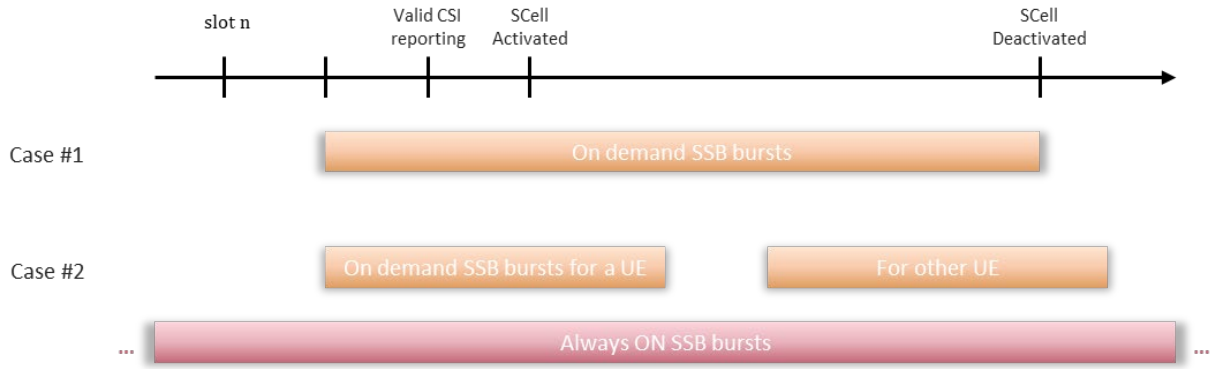
Both above methods have their own pros and cons. For example, when the failure is temporary (e.g. temporary loss of coverage), UE may benefit from a retry of the on-demand SSB procedure. But if failure occurred upon SCell activation then it may be appropriate to transmit a failure report to the network. Also, the given methods dependent on the use case - whether UE-based on demand SSB request is applicable or not. For example, if UE-based on-demand SSB request is not applicable then UE can only provide the indication of failure to the gNB.

Proposal 21: Discuss the UE behaviour for the case of failure to receive or detect the on-demand SSB. The following options can be considered:

- On-demand SSB failure indication may be sent to the network.
-UE can reinitiate the on demand SSB procedure by sending the UE request for on-demand SSB

2.6 Rate matching

PDSCH rate-matching around on-demand SSB were proposed. PDSCH on on-demand SSB SCell needs to be rate-matched around on-demand SSB. RAN1 needs to decide the UE behavior.



There could be two options:

- Option 1: PDSCH is always rate-matched around SSB according to on-demand SSB configuration irrespective of transmission of on-demand SSB.
- Option 2: PDSCH is rate-matched around SSB according to actual transmission of on-demand SSB.

In case#1 and for UE capable of OD-SSB SCell operation, from UE point of view, on-demand SSB would be always transmitted during the SCell is active, in our view. Rate-matching operation of option 1 be enough.

In case#2, OD-SSB would not always be transmitted during the SCell is active, while OD-SSB may be transmitted for other UEs. Therefore, rate-matching behaviour is likely dynamic according to actual OD-SSB transmissions. For UE capable of OD-SSB SCell operation, on-demand SSB transmission can be indicated by dedicated and/or common signalling in dynamic manner. For example, OD-SSB transmission can be indicated in DCI format 1_X when scheduling a PDSCH. Semi-static configuration of rate-matching pattern is also possible. The indication may be transmitted on the NES SCell itself and/or another cell, e.g. PCell.

In case#2, the network may configure a UE not capable of on-demand SSB SCell operation with an NES cell with semi-static rate matching pattern around possible OD-SSB (option 1). It would be also possible to avoid scheduling PDSCH in PRBs used for OD-SSB transmissions by gNB implementation without configuring rate-matching pattern around OD-SSB.

Proposal 22: RAN1 to discuss UE behaviour on PDSCH rate matching around on-demand SSB.

2.7 On-demand SSB Configuration

2.7.1 Configuration Framework

For UE to receive the on-demand SSBs, the network needs to provide the relevant configurational parameters when an SCell is added or reconfigured. Following agreement was reached in RAN1#117 for the on-demand SSB configuration:

> *Agreement (Contents) (amended as shown in red in Friday session)*
>
> *For a cell supporting on-demand SSB SCell operation, at least the following for on-demand SSB via higher layer signaling is supported.*
>
> - *Frequency of the on-demand SSB*
> - *SSB positions within an on-demand SSB burst by using signaling similar to ssb-PositionsInBurst*
> - *Periodicity of the on-demand SSB*

- *FFS: Whether more than one on-demand SSB configurations can be configured for the cell to UE*
- *FFS: Whether the RRC is newly introduced or existing RRC is reused*

Agreement

For a cell supporting on-demand SSB SCell operation, at least the followings for on-demand SSB are known to UE.

- *Sub-carrier spacing of the on-demand SSB*
- *Physical Cell ID of the on-demand SSB*
- *Location of on-demand SSB burst*
- *Downlink transmit power of on-demand SSB*
- *FFS: Other parameters*
- *FFS: Whether each of above parameters is configured/indicated explicitly or not*

Currently, SSB configuration for an SCell is provided within the *ServingCellConfigCommon* IE when an SCell is configured. The SSB parameters included within this IE are *ssb-PositionsInBurst*, *ssb-periodicityServingCell*, *ssbSubcarrierSpacing* and *ss-PBCH-BlockPower* (as indicated below for reference).

```
ServingCellConfigCommon ::= SEQUENCE {

        physCellId PhysCellId OPTIONAL, -- Cond HOAndServCellAdd,

        downlinkConfigCommon DownlinkConfigCommon OPTIONAL, -- Cond HOAndServCellAdd

        uplinkConfigCommon UplinkConfigCommon OPTIONAL, -- Need M

        …

        ssb-PositionsInBurst CHOICE {

                        shortBitmap BIT STRING (SIZE (4)),

                        mediumBitmap BIT STRING (SIZE (8)),

                        longBitmap BIT STRING (SIZE (64))

                } OPTIONAL, -- Cond AbsFreqSSB

        ssb-periodicityServingCell ENUMERATED { ms5, ms10, ms20, ms40, ms80, ms160, spare2,
        spare1 } OPTIONAL, -- Need S

        ssbSubcarrierSpacing SubcarrierSpacing OPTIONAL, -- Cond HOAndServCellWithSSB

        ss-PBCH-BlockPower INTEGER (-60..50),

        …
```

Additionally, the SSB frequency can be indicated within *absoluteFrequencySSB* IE of *frequencyInfoDL* which is mandatorily present when SCell contains SSB transmission.

For Case#1, the given IEs can be reused for on-demand SSB (as on-demand SSB is the only SSB which shall be transmitted). Some of the information like SSB frequency and/or SSB positions within an on-demand SSB burst can be signalled using existing IEs (*absoluteFrequencySSB* and *ssb-periodicityServingCell*) while additional IEs can be introduced for indicating aspects specific to on-demand SSB operation.

Proposal 23: For Case#1, on-demand SSB configuration can reuse the SCell SSB IEs (absoluteFrequencySSB, ssb-periodicityServingCell, ssb-periodicityServingCell, ssbSubcarrierSpacing, ss-PBCH-BlockPower) included within ServingCellConfigCommon.

-Additional IEs can be introduced for remaining aspects specific to on demand SSB operation.

For Case#2 where always-on SSB is also present, the above IEs are expected to be used for indicating the configuration of always-on SSB. In that case, we must consider how to provide the configuration of on-demand SSB.

If on-demand SSB is transmitted in the same frequency as always-on SSB (for e.g. on-demand SSB time multiplexed with always-on SSB), then on-demand SSB can utilize most of the parameters provided for always-on SSB. Any additional parameters (e.g. time offset wrt to always-on SSB occasions can be indicated explicitly for on-demand SSB).

Proposal 24: For Case#2, if on-demand SSB is transmitted in the same frequency as always-on SSB, the on-demand SSB and always-on SSB can share some of the transmission parameters (absoluteFrequencySSB, ssb-periodicityServingCell, ssb-periodicityServingCell, ssbSubcarrierSpacing, ss-PBCH-BlockPower).

-Additional IEs can be introduced for other remaining aspects specific to on-demand SSB operation.

When on-demand SSB is transmitted in a different frequency than always-on SSB (e.g. when on-demand SSB is not CD-SSB), then it may be worthwhile to reuse the configuration for NCD-SSB.

The IE for NCD-SSB was defined for RedCap which is used by RedCap UEs for performing all operations (like sync, RRM) that would have been performed using CD-SSB. Most of the transmission parameters for NCD-SSB are shared with CD-SSB however some additional parameters (*absoluteFrequencySSB*, *ssb-Periodicity* and *ssb-TimeOffset*) may be different and are provided within *NonCellDefiningSSB* IE of *BWP-DownlinkDedicated* (as shown below for reference).

```
NonCellDefiningSSB-r17 ::= SEQUENCE {

        absoluteFrequencySSB-r17 ARFCN-ValueNR,

        ssb-Periodicity-r17 ENUMERATED { ms5, ms10, ms20, ms40, ms80, ms160, spare2, spare1 }
        OPTIONAL, -- Need S

        ssb-TimeOffset-r17 ENUMERATED { ms5, ms10, ms15, ms20, ms40, ms80, spare2, spare1 }
        OPTIONAL, -- Need S

        ...

}
```

Proposal 25: For Case#2, if on-demand SSB is not transmitted in the same frequency as always-on SSB, the on-demand SSB configuration can be provided using NonCellDefiningSSB-r17

-Additional IEs can be introduced for remaining aspects specific to on-demand SSB operation.

2.7.2 Additional Parameters for On-demand SSB Operation

Here, we discuss the additional parameters which are required for on-demand SSB operation.

For legacy operations, UEs assume that SSB shall be transmitted periodically by the gNB and schedule their measurement procedures accordingly. However, for the case of on-demand SSB, the UE needs to be indicated whether SSB associated to a serving cell is transmitted periodically or on-demand. Based on this information, UE can apply the parameters appropriately for the SSB detection. For example, if gNB indicates to UE that SSB is of type “on-demand” then UE may not try to perform any SSB detection unless it receives signaling from the gNB indicating start of on-demand SSB. Note that presence of such information becomes even more relevant when we consider that for Case#1 gNB may configure parameters for both on-demand SSB and always-on SSB using same set of IEs as used for always-on SSB. This information to differentiate between on-demand SSB and always-on SSB cases can either be provided explicitly using a dedicated parameter or can be provided implicitly to UE based on presence of another parameter (e.g. time window of SSB transmission).

Further for the case when on-demand SSB is UE initiated, the gNB is also expected to provide the parameters required to initiate the UE request. For example, if UE request needs to be initiated using PUCCH resources over PCell then PUCCH configuration to be used for UE request should be included

within the configuration. Time domain location of on-demand SSB and number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated.

Other than the above-mentioned parameters, the UE would also require the configuration of the time window for how long to monitor for on-demand SSB occasions once transmission is indicated by the gNB. Thus, the gNB also needs to indicate the information of the time window during which on-demand SSB can be monitored by the UE once on-demand SSB transmission start is indicated.

Proposal 26: For a cell supporting on-demand SSB SCell operation, gNB indicates the following to the UE:

- ***Whether a configured SSB is always-on or on-demand transmitted. FFS whether this indication is provided explicitly or implicitly using another parameter.***
- ***Time domain location of on-demand SSB***
- ***The number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated***

For Case#2 where both on-demand SSB and always-on SSB are transmitted, most of the parameters can be common between on-demand SSB and always-on SSB including SCS, SSB power. However, some of the parameters can be configured separately for on-demand SSB.

For time domain location of on-demand SSB, following options were selected in RAN1#119 [1].

Agreement

- *For a cell supporting on-demand SSB SCell operation, support to configure time domain location of on-demand SSB per on-demand SSB periodicity by RRC for both Case #1 and Case #2.*
  - *For Case #1 (i.e., No always-on SSB on the cell),*
    - *Based on two parameters, where one is to indicate SFN offset from a reference point and the other is to indicate half frame index*
      - *The reference point is SFN which satisfies (SFN index *10) modulo (OD-SSB periodicity) = 0*
      - *If SFN offset parameter is NOT configured, UE assumes SFN offset set to 0.*
      - *If half frame index parameter is NOT configured, UE assumes half frame index set to 0.*
      - *The value range of SFN offset is 0 to 15 unless longer periodicity for on-demand SSB than 160 ms is introduced.*
      - *The value range of half frame index is 0 or 1.*
  - *For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), down-select one of the following alternatives.*
    - *Alt A: Same as for Case #1*
    - *Alt B: Based on a single parameter which is to indicate the time offset between always-on SSB and on-demand SSB (e.g., similar to ssb-TimeOffset)*

As discussed in previous section, for Case#2 we have a slight preference to reuse the parameters which are already present for NCD-SSB. The NCD-SSB time domain location is currently provided in specification with respect to the time domain location of CD-SSB. This is aligned with Alt-B listed in the above agreement. Hence we prefer that the SSB burst occasions for on-demand SSB can be provided wrt the SSB burst occasions of always-on SSB for Case#2.

Proposal 27: For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), support Alt B to configure time domain location of on-demand SSB per on-demand SSB periodicity by RRC: Based on a single parameter which is to indicate the time offset between always-on SSB and on-demand SSB (e.g., similar to ssb-TimeOffset).

Additionally, on-demand SSB can have same or different periodicity as compared to always-on SSB hence apart from the time offset between always-on SSB and on-demand SSB, the gNB would also need to configure the periodicity of on-demand SSB independent of the periodicity of always-on SSB.

Proposal 28: For Case#2, gNB configures the periodicity of on-demand SSB in addition to the periodicity of always-on SSB.

3 Conclusion

From the discussion, we have the following proposals:

Observation 1: For Scenario #3B and Case#2, on-demand SSB transmission can improve the beam management performance for an activated SCell when the always-on SSB is transmitted with longer periodicity.

Proposal 1: Support on-demand SSB operation for Scenario #3B Case #1 and Scenario #3B Case#2. Further discuss the applicability of Scenario#3A.

Observation 2: For Case#1, gNB does not need to newly trigger on-demand SSB for a UE if the SCell is already active for another UE (FFS: indication).

Observation 3: For Case#1, on-demand SSB is not expected to be deactivated as long as at least one UE is active on the Cell even when the SCell is deactivated for a UE for which the network triggered the on-demand SSB.

Observation 4: On-demand SSB would be transmitted periodically for a while as long as at least one UE is active on the cell, as SCell is a capacity cell and traffic on the capacity cell would not be low.

Proposal 2: When on-demand SSB is transmitting periodically, NES cell can be used as an SCell for non-NES UEs irrespective of whether on-demand SSB is CD-SSB.

Proposal 3: At least for case#1, on-demand SSB can be CD-SSB and transmitted on synch-raster with assumption the network ensures periodic CD-SSB transmission when the NES cell is activated for any UE.

Observation 5: Legacy UEs, connected to an NES cell, may show unpredictable behaviour and potential synchronization loss if on-demand SSB share the same frequency as always-on SSBs.

Proposal 4: Support Alt 1: If always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.

Proposal 5: Support Alt A: If always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be same or different from the frequency location of always-on SSB, subject to its configuration.

Observation 6: Using MAC CE or RRC based indication for on-demand start indication is expected to increase signalling overhead when indication is sent for scenarios not involving SCell activation.

Proposal 6: Support on-demand SSB indication via group-common DCI for Scenario#2 and Scenario#3.

Proposal 7: On-demand SSB for SCell may be enabled via DCI format 1_x on PCell with a carrier indication field to indicate the applicable carrier.

Proposal 8: Support Option 4 or Option 4A in addition: On-demand SSB transmission, is deactivated when UE receives SCell deactivation MAC-CE for the activated SCell or when the timer for SCell deactivation is expired.

Proposal 9: Support Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated.

Proposal 10: Support explicit RRC configuration for the value of N.

Proposal 11: RAN1 to discuss the case where SCell with on-demand SSB transmission and cell with on-demand SSB indication have different numerology.

Observation 7-: NR currently supports indication of smtc within SCellConfig during SCell addition which allows UE to optimise the SSB search. The smtc time reference is with respect to the PCell and contains the same periodicity value as ssbperiodicityServingCell indicated in sCellConfigCommon.

Proposal 12: For the case where SCell and the reference cell (where UE receives on-demand SSB indication) have different numerology, discuss further what time/numerology reference is used for the configuration of SSB time domain positions provided to the UE.

Proposal 13: For Case#2, when on-demand SSB and always-on SSB overlap in time domain, consider always-on SSB is given higher priority than on-demand SCell SSB request.

Proposal 14: For Case#1 and Case#2, within a time window, combine multiple on-demand SSB transmissions due to multiple on-demand SSB requests into one in order to maximize network energy saving.

Proposal 15: Support Option 2: A CSI report configuration is associated with one of always-on SSB and on-demand SSB.

Proposal 16: The on-demand SSB indication shall be provided to the UE before the start of the corresponding CSI report transmissions.

Proposal 17: Before SCell activation, gNB to indicate one of on-demand SSB or always-on SSB for all configured periodic SSB measurements.

Proposal 18: After SCell activation, only aperiodic on-demand SSB measurements are supported for NES SCell operation.

Proposal 19: For aperiodic CSI reporting based on on-demand SSB consider one of the following options:

> ***-Option-1: Support group-common based DCI indication for on-demand SSB indication***
> ***-Option-2: Support indication of on-demand SSB within the CSI report trigger indication***

Proposal 20: Discuss other cases (e.g. RACH initiation upon TAT expiry) for which on-demand SSB transmission may be required.

Proposal 21: Discuss the UE behaviour for the case of failure to receive or detect the on-demand SSB. The following options can be considered:

- On-demand SSB failure indication may be sent to the network.
-UE can reinitiate the on demand SSB procedure by sending the UE request for on-demand SSB

Proposal 22: RAN1 to discuss UE behaviour on PDSCH rate matching around on-demand SSB.

Proposal 23: For Case#1, on-demand SSB configuration can reuse the SCell SSB IEs (absoluteFrequencySSB, ssb-periodicityServingCell, ssb-periodicityServingCell, ssbSubcarrierSpacing, ss-PBCH-BlockPower) included within ServingCellConfigCommon.

-Additional IEs can be introduced for remaining aspects specific to on demand SSB operation.

Proposal 24: For Case#2, if on-demand SSB is transmitted in the same frequency as always-on SSB, the on-demand SSB and always-on SSB can share some of the transmission parameters (absoluteFrequencySSB, ssb-periodicityServingCell, ssb-periodicityServingCell, ssbSubcarrierSpacing, ss-PBCH-BlockPower).

-Additional IEs can be introduced for other remaining aspects specific to on-demand SSB operation.

Proposal 25: For Case#2, if on-demand SSB is not transmitted in the same frequency as always-on SSB, the on-demand SSB configuration can be provided using NonCellDefiningSSB-r17

-Additional IEs can be introduced for remaining aspects specific to on-demand SSB operation.

Proposal 26: For a cell supporting on-demand SSB SCell operation, gNB indicates the following to the UE:

- ***Whether a configured SSB is always-on or on-demand transmitted. FFS whether this indication is provided explicitly or implicitly using another parameter.***
- ***Time domain location of on-demand SSB***
- ***The number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated***

Proposal 27: For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), support Alt B to configure time domain location of on-demand SSB per on-demand SSB periodicity by RRC: Based on a single parameter which is to indicate the time offset between always-on SSB and on-demand SSB (e.g., similar to ssb-TimeOffset).

Proposal 28: For Case#2, gNB configures the periodicity of on-demand SSB in addition to the periodicity of always-on SSB.

4 References

[1] Chairman's notes RAN1#119

[2] Chairman's notes RAN1#118bis

[3] Chairman's notes RAN1#118

[4] TS 38.300 v18.1.0

[5] TS 38.213 v18.2.0