3GPP TSG RAN WG1 #120 **R1-2500953**

Greece, Athens, February 17th – February 21st, 2025

Agenda Item: **9.5.1**

Source: **LG Electronics**

Title: **On-demand SSB SCell operation**

Document for: **Discussion and decision**

1. Introduction

In RAN1#118bis, the following agreements related to on-demand SSB SCell operation were made [1].

Agreement

Response to Q1 (What is the relation in terms of periodicity between always-on SSB and OD-SSB?) of Obj.1:

- The periodicity of on-demand SSB is one of 5 ms, 10 ms, 20 ms, 40 ms, 80 ms, or 160 ms.
- 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.

Further update to be made based on RAN1#119 progress.

Agreement

Response to Q3 (What is the relation in terms of frequency location between the always-on SSB and OD-SSB?) of Obj.1:

- 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?) of Obj.1:

- 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?) of Obj.1:

- 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 and provide our views on on-demand SSB SCell operation for NES.

2. Network-triggered on-demand SSB

Agreement

- 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.

From our understanding, always-on SSB that is not CD-SSB in the above agreement can be NCD-SSB configured with the higher layer parameter *nonCellDefiningSSB*. This type of NCD-SSB can be configured in each dedicated BWP if there is no CD-SSB within the dedicated BWP. Therefore, according to the above agreement, the frequency location of on-demand SSB is the same as the frequency location of this type of NCD-SSB, so on-demand SSB can be located in each dedicated BWP where the corresponding NCD-SSB is configured. With this regard, it makes sense to allow on-demand SSB configuration per BWP at least for Case #2. In addition, considering the unified design, we prefer to support on-demand SSB configuration per BWP for Case #1 as well.

Proposal #1: Support on-demand SSB configuration per BWP similar to NCD-SSB configured with the higher layer parameter *nonCellDefiningSSB*.

2.1. Signaling of on-demand SSB

Agreement

For the identified scenarios and cases (as per RAN1#116 agreement), on-demand SSB can be indicated 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.
- Notes:
    - Scenario #2A refers to
        - "When UE receives SCell activation command (e.g., as defined in TS 38.321)"
    - Scenario #3A refers to
        - "After UE receives SCell activation command (e.g., as defined in TS 38.321) until SCell activation is completed"
    - Scenario #3B refers to
        - "When SCell activation is completed and SCell is activated" or
        - "After SCell activation is completed and SCell is activated"
    - For discussion purpose under AI 9.5.1, always-on SSB is SSB supported in Rel-18 specifications.
    - Timing for on-demand SSB transmission (e.g. when the triggered SSB starts and ends) will be separately discussed.

Regarding FFS points in the above agreement, it should be discussed and concluded whether on-demand SSB can be only indicated in Scenario #2 and Scenario #2A on Case #1 and Case #2, or on-demand SSB can be also indicated/activated in Scenario #3A and Scenario #3B on Case #1 and Case #2(gray-highlighted in the agreement). It is noted that on-demand SSB is operated in a cell-specific manner and different UEs may experience different scenarios. For instance, when gNB indicates an on-demand SSB for UE#1 which is in Scenario #2 or 2A, the other UE#2 in Scenario 3B may need to be aware of the existence of the on-demand

SSB at least for RACH occasion validation and data rate-matching, as illustrated in Section 3. Therefore, on-demand SSB transmission indication at least in Scenario #3B (after SCell activation completion) should be supported regardless of Case #1 and Case #2. Additionally, it might need to discuss how to handle the case where UE receives on-demand SSB transmission indication signaling in Scenario #3A if on-demand SSB cannot be indicated in Scenario #3A.

Proposal #2: In addition to agreed scenarios and cases, on-demand SSB can be indicated by gNB at least for the following scenarios/cases.

- **Scenario #3B and Case #1**
- **Scenario #3B and Case #2**

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 RAN1#119 meeting, 2 options were agreed to deactivate on-demand SSB transmission from a UE perspective. N means the number of on-demand SSB burst transmission after on-demand SSB is indicated and we need to discuss N in more details, e.g., what is the value range (including the minimum and maximum values) of N and how to indicate/configure it to UEs. Determination of the minimum and maximum values for N seems to be within the work scope of RAN4. Meanwhile, we think that the infinite (or non-numerical) value can be one out of candidate N values. If a UE is configured/indicated with this infinite (or non-numerical) value for N, the UE expects continuous and periodic transmission of on-demand SSB. In addition, it can be discussed whether Option 1 can be used together with Option 2. For instance, if N is configured/indicated as a specific value (e.g., an integer value or infinite/non-numerical value), we can discuss UE behavior upon the reception of explicit indication of deactivation for on-demand SSB (via MAC-CE).

Proposal #3: Consider the infinite/non-numerical value as one of candidate N values.

- **If a UE is configured/indicated with this infinite/non-numerical value for N, the UE expects continuous and periodic transmission of on-demand SSB.**

2.2. Frequency location of on-demand SSB Burst

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.

First, we are against Alt 2 because on-demand CD-SSB being located on the same sync raster of always-on CD-SSB can give an impact to legacy UE, and because of inconsistent MIB between always-on CD-SSB and on-demand CD-SSB if those SSBs are located on the same sync raster. Alt 3 is not preferable, as on-demand SSB cannot be configured in anywhere of an SCell if the SCell has only one always-on SSB which is CD-SSB on a sync raster. Thus, if always-on SSB is CD-SSB on a sync raster, the frequency location of on-demand SSB is different from the frequency location of always-on SSB.

When always-on SSB is CD-SSB and not on a sync raster, the frequency location of on-demand SSB does not need to be always the same as the frequency location of always-on SSB. Without the impact to legacy UEs, 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 C is not preferable as on-demand SSB cannot be configured in anywhere of an SCell if the SCell has only one always-on SSB which is CD-SSB not on a sync raster.

Additionally, if there is a concern for the case where the frequency location of on-demand SSB is different from the frequency location of always-on SSB from UE complexity/implementation point of view, it can be considered to impose a restriction that always-on SSB and on-demand SSB are located within that same BWP.

Proposal #4: Adopt Alt 1 and Alt A and further discuss whether the limitation that always-on SSB and on-demand SSB are located within the same BWP is needed or not.

- **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 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**

2.3. Time location configuration of on-demand SSB burst in Case 2

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*)

For Case #1, signalling details for the time location configuration were decided in RAN1#119 while for Case #2, two alternatives are on the table and to be down-selected. Between Alt A and Alt B, we prefer Alt B which is similar to the time location configuration for NCD-SSB configured with the higher layer parameter *nonCellDefiningSSB*. Considering that UE already knows the time domain locations (i.e., SFN offset and half frame index) for always-on SSB, there is no need to additionally indicate SFN offset and half frame index separately for on-demand SSB and the single new parameter (e.g., *od-ssb-TimeOffset*) from the reference time

of always-on SSB is sufficient. Furthermore, if this new parameter is NOT configured, UE assumes that the time offset between always-on SSB and on-demand SSB equals to 0.

Proposal #5: For Case #2, adopt Alt B (i.e., 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*)).

- **If the parameter is NOT configured,**
  - **UE assumes the parameter set to 0**

2.4. TX behavior of on-demand SSB burst

Proposal #5-2 (Time instance A for RRC):

- For SSB burst(s) indicated by on-demand SSB SCell operation via a RRC, UE expects that on-demand SSB burst(s) is transmitted from time instance A_RRC which is determined as follows.
  - Time instance A_RRC is the beginning of the first slot containing the first actually transmitted SSB index within the first "possible" on-demand SSB burst which is at least T_RRC slots after the last slot overlapping with the PDSCH containing the RRC
    - 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
  - RAN2/RAN4 to confirm the value for T_RRC
- Above applies at least for the case where SCell with on demand SSB transmission and cell with signalling transmission have the same numerology.

Additional remaining aspect for time instance A determination is when UE can expect SSB reception after receiving the indication for on-demand SSB transmission via a RRC message. In our opinion, without definition for time instance A_RRC, UEs cannot determine the first timing when on-demand SSB is transmitted after receiving RRC signalling to indicate/activate on-demand SSB, particularly when N (=the number of on-demand SSB bursts to be transmitted after on-demand SSB is indicated) is indicated/configured. For example, for SSB burst(s) indicated by on-demand SSB SCell operation via RRC, according to TS 38.331, RRC message requires UE to consider RRC processing time. RRC processing time is given by 16 msec for RRC reconfiguration message for SCell addition/release (alternatively, the indication of on-demand SSB can be included in the RRC message with SCell activation command). As depicted in Figure 1, 16 msec processing time can be taken as the starting point to decide time instance A for SSB burst(s) indicated by on-demand SSB SCell operation via RRC signalling. RAN2/RAN4 can be involved to determine the exact value for RRC processing time.

Proposal #6: When PDSCH including RRC for on-demand SSB transmission indication is received at slot n, UE can expect on-demand SSB is periodically transmitted from time instance A which is the beginning of the first slot containing candidate SSB index 0 of on-demand SSB burst from the slot that is after slot n + X· $N_{\text{slot}}^{\text{subframe},\mu}$.

- **FFS: The value of X by taking 16+K(if additional consideration is not needed, K=0) as the starting point**

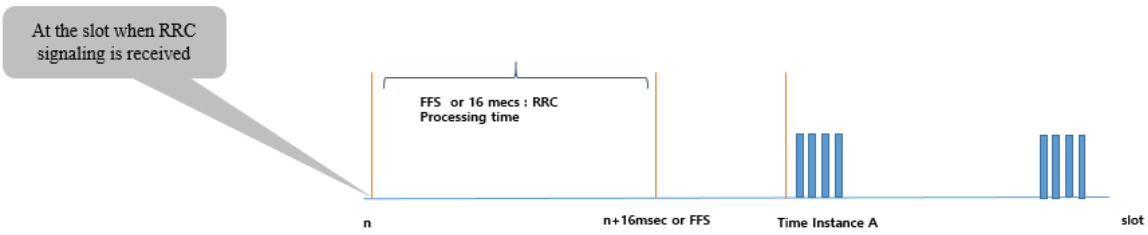

Figure 1. Example of where time instance A is positioned: On-demand SSB indicated via RRC

Agreement

The following agreement from RAN1#116 is modified

- For SSB burst(s) indicated by on-demand SSB SCell operation, study at least the following options.
  - Option 1: UE expects that on-demand SSB burst(s) is periodically transmitted from time instance A.
  - Option 1A: UE expects that on-demand SSB burst(s) is periodically transmitted from time instance A until gNB turns OFF the on demand SSB
  - Option 2: UE expects that on-demand SSB burst(s) is transmitted from time instance A to time instance B and not transmitted after time instance B.
  - Option 3: UE expects that on-demand SSB burst(s) is transmitted N times after time instance A and not transmitted after N on-demand SSB bursts are transmitted.
  - Option 4: UE expects that on-demand SSB burst(s) is transmitted with a periodicity from time instance A to time instance B and with the other periodicity after time instance B.
  - FFS: The combination of above options
  - FFS: How to define time instance A/B and the value of N per option
  - FFS: Each option is applicable to which Cases or Scenarios (as per the previous agreement)

Since it was agreed to support explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication in RAN1#119, time instance B in Option 1A or 2 from the above agreement needs to be determined. Similar to time instance A, when a UE receives explicit indication of

deactivation for on-demand SSB to be transmitted via MAC CE signalled at slot n, the UE expects that on-demand SSB is not transmitted after slot n+Y (e.g., Y=MAC CE processing time). Thus, to avoid UE's confusion, it seems reasonable that gNB should not signal the activation(indication) for on-demand SSB between slot n and slot n+Y.

Proposal #7: If a UE receives MAC CE in slot n for deactivating on-demand SSB via MAC-CE, the UE expects that on-demand SSB is not transmitted after slot n+Y.

- **Further discuss the value of Y.**

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), study at least the following Mux-Cases.

- Mux-Case #1: No time-domain overlap between always-on SSB and on-demand SSB
- Mux-Case #2: Always-on SSB and on-demand SSB overlap at least in time or frequency domain

Mux-Case #1 requires gNB to configure an adequate time domain in order that no time-domain overlapping between always-on SSB and on-demand SSB occurs. For Mux-case #2, when always-on SSB and on-demand SSB overlap both in time and frequency domain, on-demand SSB should be skipped by gNB to avoid the conflict because on-demand SSB is unseen to legacy UEs. Additionally, the case that the two SSBs (having different half frame indexes) are located within 10ms duration in the time domain can be discussed/studied further.

Proposal #8: When on-demand SSB and always-on SSB overlap both in time domain and frequency domain, on-demand SSB is dropped.

2.5. Contents of on-demand SSB configuration/indication

Proposal #5-3 (RRC+MAC-CE indication):

For a cell supporting on-demand SSB SCell operation, in addition to periodicity of the on-demand SSB, for the following parameter(s), multiple candidate values can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.

- SSB positions within an on-demand SSB burst
- The number of on-demand SSB bursts to be transmitted after on-demand SSB is indicated

For the two parameters which are SSB positions within an-demand SSB burst and the number of on-demand SSB bursts to be transmitted, multiple candidate values can be configured by RRC (in addition to on-demand SSB periodicity) and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the on-demand SSB transmission indication for the cell. SSB positions can have multiple candidate values if SSB indices within on-demand SSB burst are subset of SSB indices within always-on SSB burst. In addition, time domain locations of on-demand SSB (i.e., SFN offset and half frame index for Case #1 or *od-ssb-TimeOffset* for Case #2) can be also included in parameters having multiple candidate values.

As a signalling detail to implement above Proposal #5-3, we suggest that RRC or MAC CE signalling for on-demand SSB transmission indication indicates an index for one of multiple pre-configured OD-SSB configurations where each of OD-SSB configurations includes a set of parameters (e.g., periodicity, the number of on-demand SSB bursts, SSB position, Time domain locations and so on). This approach requires less signalling overhead than allocating a separate field for each parameter in RRC or MAC CE signalling for on-demand SSB transmission indication. If each parameter is indicated separately in MAC CE without grouping the multiple parameters into a set, the structure of MAC CE to indicate on-demand SSB can be more complicated.

Proposal #9: Support more than one on-demand SSB configurations that are provided by RRC signalling.

- **One index of multiple on-demand SSB configurations is indicated by signalling for on-demand SSB transmission indication.**
- **One on-demand SSB configuration includes a set of the following parameters for which multiple candidate values can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication**
  - **On-demand SSB periodicity**
  - **Time domain location (i.e., SFN offset and half frame index for Case #1 and offset between always-on SSB and on-demand SSB for Case #2) of on-demand SSB burst**
  - **The number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated**
  - **SSB positions within an on-demand SSB burst**

2.6. L1 Measurement with On-demand SSB

In RAN1#118bis meeting, there was the following agreement on the measurement with on-demand SSB in SCell operation. This section will handle resource configuration for CSI reporting on L1 measurement, the frequency position for on-demand SSB during SCell activation and UE behavior of CSI reporting on L1 measurement after on-demand SSB is terminated.

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

The first aspect to be discussed to support L1 measurement based on on-demand SSB is how to configure on-demand SSB as the measurement resource for CSI report configuration for L1 measurement. In detail, it can be further discussed whether on-demand SSB can be differentiated from always-on SSB as measurement resource at the level of *CSI-resourceConfig*, *csi-RS-ResourceSetList* or *csi-SSB-ResourceSetList*. Between two options in the above agreement, Option 2 can be taken as the baseline for its simplicity. If Option 1 can be adopted in addition to Option 2, at least the following issues can be handled.

- Whether two SSBs are used or one of SSBs is used for measurement/reporting when on-demand SSB is activated
- CPU occupation rule when two SSBs are used for measurement/reporting

Proposal #10: For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), take Option 2 (i.e., A CSI report configuration is associated with one of always-on SSB and on-demand SSB) as the baseline for CSI report configuration for L1 measurement.

When UE receives SCell activation command via MAC CE or RRC, the first active BWP is determined by the higher layer parameter *firstActiveDownlinkBWP-Id*. So, it seems necessary to discuss whether on-demand SSB needs to be positioned within the frequency range of the first active BWP. If the frequency resource of on-demand SSB in Scenario 3A is configured outside of the first active BWP, UE may require to measure on-demand SSB outside of the active BWP.

Proposal #11: Discuss the relationship between the frequency position of on-demand SSB and the frequency range of the first active BWP given by the higher layer parameter *firstActiveDownlinkBWP-Id*.

Different form always-on SSB, on-demand SSB is not always transmitted in the cell. Hence, there could be the case where on-demand SSB is absent when UE is configured/indicated to report measurement result based on on-demand SSB. In this case, UE may omit the corresponding measurement report or report a value (e.g., pre-defined/lowest value, latest valid reported value), without performing measurement based on on-demand SSB (except for the case where the gap between time instance B and reporting time is less than a certain duration). Alternatively, UE may recognize that deactivated on-demand SSB is re-activated by indicating/triggering measurement report.

Proposal #12: Discuss UE behaviour to perform the measurement/report based on on-demand SSB after the on-demand SSB is deactivated.

3. Consideration to support on-demand SSB SCell operation

SSB transmitted on an SCell has a plenty of functionalities in NR system, such as time/frequency synchronization, path-loss estimation, QCL reference signal, beam failuure, and so on. Therefore, it should be discussed which functionalities can be utilized from the SSB transmitted after on-demand SSB procedure. For instance, for the purpose of timing reference or path-loss estimation, the SCell's SSB can be used if it has been transmitted for longer than a specific period of time. For another instance, it can be discussed how to handle the case where on-demand SSB configured as BFD-RS is deactivated.

Proposal #13: Discuss how to utilize SSB transmitted after on-demand SSB procedure, for the purposes of time/frequency synchronization, path-loss estimation, QCL reference signal, beam failure, and so on.

In legacy NR, considering the importance of SSB, SSB reception was prioritized over other signal/channel's transmission/reception when SSB is collided with other signals/channels. However, if SSB transmission can be adapted based on on-demand SSB procedure, the following SSB collision rules can be re-considered. One simple solution could be to perform the following procedure by assuming union of all possible on-demand SSB transmissions or currently activated on-demand SSB transmissions.

- RACH occasion validation,
- PDCCH monitoring behaviour,
- DL/UL signal/channel reception/transmission behaviour, etc.

Proposal #14: Discuss how UE performs RACH occasion validation, PDCCH monitoring, and DL/UL signals/channels reception/transmission, if the SSB transmission can be (de)activated based on on-demand SSB procedure.

4. Higher layer signaling aspects

Agreement (RAN1#117)

- For a cell supporting on-demand SSB SCell operation, at least the following for on-demand SSB via higher layer RRC 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 (RAN1#118bis)

For a cell supporting on-demand SSB SCell operation, support to provide at least the following parameters for on-demand SSB configuration by RRC at least for Case #1.

- Sub-carrier spacing of the on-demand SSB
  - FFS if this can be absent
- Physical Cell ID of the on-demand SSB

- FFS: Time domain location of on-demand SSB burst such as SFN offset and half frame index
- Downlink transmit power of on-demand SSB
- FFS: The number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
- FFS whether the above parameters are configured by reusing legacy RRC parameters or new RRC parameters

As captured above, there is FFS point related to whether legacy RRC parameters or new RRC parameters are used for on-demand SSB configuration. At least for Case #1, new RRC parameters are required to differentiate SSB-less SCell (where SSB-related parameters are not provided at all) from a cell supporting on-demand SSB SCell operation. Furthermore, introducing new RRC parameters not only for Case #1 but also for Case #2 would be a cleaner solution.

Proposal #15: Introduce NEW higher layer parameters to configure at least the followings for on-demand SSB, both for Case #1 and Case #2. For Case #2, if the following parameter is NOT provided, the corresponding value configured for always-on SSB is applied for on-demand SSB.

- **Frequency of the on-demand SSB**
- **SSB positions within an on-demand SSB burst by using signaling similar to *ssb-PositionsInBurst***
- **Sub-carrier spacing of the on-demand SSB**
- **Physical Cell ID of the on-demand SSB**
- **Downlink transmit power of on-demand SSB**

As illustrated in Section 2.5, it would be more efficient to introduce a new RRC parameter incorporating a set of parameters related to on-demand SSB, rather than to separately signal those via MAC CE for on-demand SSB activation. With this approach, MAC CE (and RRC) for on-demand SSB activation can indicate an index of multiple sets of on-demand SSB parameters.

Proposal #16: Introduce a NEW higher layer parameter (e.g., *od-ssb-ConfigList*) in which a set of parameters for on-demand SSB at least including the followings are included. A signaling (i.e., MAC CE or RRC) for on-demand SSB activation indicates an index within *od-ssb-ConfigList*.

- **On-demand SSB periodicity**
- **Time domain location (i.e., SFN offset and half frame index for Case #1 and offset between always-on SSB and on-demand SSB for Case #2) of on-demand SSB burst**

5. Conclusions

In this contribution, on-demand SSB SCell operation for NES was discussed, and the followings were proposed.

Proposal #1: Support on-demand SSB configuration per BWP similar to NCD-SSB configured with the higher layer parameter *nonCellDefiningSSB*.

Proposal #2: In addition to agreed scenarios and cases, on-demand SSB can be indicated by gNB at least for the following scenarios/cases.

- **Scenario #3B and Case #1**
- **Scenario #3B and Case #2**

Proposal #3: Consider the infinite/non-numerical value as one of candidate N values.

- **If a UE is configured/indicated with this infinite/non-numerical value for N, the UE expects continuous and periodic transmission of on-demand SSB.**

Proposal #4: Adopt Alt 1 and Alt A and further discuss whether the limitation that always-on SSB and on-demand SSB are located within the same BWP is needed or not.

- **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 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**

Proposal #5: For Case #2, adopt Alt B (i.e., 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*)).

- **If the parameter is NOT configured,**
  - **UE assumes the parameter set to 0**

Proposal #6: When PDSCH including RRC for on-demand SSB transmission indication is received at slot n, UE can expect on-demand SSB is periodically transmitted from time instance A which is the beginning of the first slot containing candidate SSB index 0 of on-demand SSB burst from the slot that is after slot n + X· $N_{\text{slot}}^{\text{subframe},\mu}$.

- **FFS: The value of X by taking 16+K(if additional consideration is not needed, K=0) as the starting point**

Proposal #7: If a UE receives MAC CE in slot n for deactivating on-demand SSB via MAC-CE, the UE expects that on-demand SSB is not transmitted after slot n+Y.

- **Further discuss the value of Y.**

Proposal #8: When on-demand SSB and always-on SSB overlap both in time domain and frequency domain, on-demand SSB is dropped.

Proposal #9: Support more than one on-demand SSB configurations that are provided by RRC signalling.

- **One index of multiple on-demand SSB configurations is indicated by signalling for on-demand SSB transmission indication.**
- **One on-demand SSB configuration includes a set of the following parameters for which multiple candidate values can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication**
  - **On-demand SSB periodicity**
  - **Time domain location (i.e., SFN offset and half frame index for Case #1 and offset between always-on SSB and on-demand SSB for Case #2) of on-demand SSB burst**
  - **The number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated**
  - **SSB positions within an on-demand SSB burst**

Proposal #10: For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), take Option 2 (i.e., A CSI report configuration is associated with one of always-on SSB and on-demand SSB) as the baseline for CSI report configuration for L1 measurement.

Proposal #11: Discuss the relationship between the frequency position of on-demand SSB and the frequency range of the first active BWP given by the higher layer parameter *firstActiveDownlinkBWP-Id*.

Proposal #12: Discuss UE behaviour to perform the measurement/report based on on-demand SSB after the on-demand SSB is deactivated

Proposal #13: Discuss how to utilize SSB transmitted after on-demand SSB procedure, for the purposes of time/frequency synchronization, path-loss estimation, QCL reference signal, beam failure, and so on.

Proposal #14: Discuss how UE performs RACH occasion validation, PDCCH monitoring, and DL/UL signals/channels reception/transmission, if the SSB transmission can be (de)activated based on on-demand SSB procedure.

Proposal #15: Introduce NEW higher layer parameters to configure at least the followings for on-demand SSB, both for Case #1 and Case #2. For Case #2, if the following parameter is NOT provided, the corresponding value configured for always-on SSB is applied for on-demand SSB.

- **Frequency of the on-demand SSB**
- **SSB positions within an on-demand SSB burst by using signaling similar to *ssb-PositionsInBurst***
- **Sub-carrier spacing of the on-demand SSB**
- **Physical Cell ID of the on-demand SSB**
- **Downlink transmit power of on-demand SSB**

Proposal #16: Introduce a NEW higher layer parameter (e.g., *od-ssb-ConfigList*) in which a set of parameters for on-demand SSB at least including the followings are included. A signaling (i.e., MAC CE or RRC) for on-demand SSB activation indicates an index within *od-ssb-ConfigList*.

- **On-demand SSB periodicity**
- **Time domain location (i.e., SFN offset and half frame index for Case #1 and offset between always-on SSB and on-demand SSB for Case #2) of on-demand SSB burst**

6. References

[1] RAN1#119 chairman’s note