3GPP TSG RAN WG1 #120 **R1-2500291**

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

Source: **CMCC**

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

Agenda item: **9.5.1**

Document for: **Discussion & Decision**

1. Introduction

In RAN1#119 meeting [1], the following agreements were made regarding indication method and configuration of on-demand SSB in SCell.

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

- 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

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

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

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 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

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 concentrate on discussing the applicable scenario, indication method and L1 measurement of on-demand SSB in SCell for connected UEs.

2. Discussion on whether on-demand SSB is CD-SSB

Regarding the UE assumption on SSB transmission on a cell supporting on-demand SSB SCell operation, RAN1#118 meeting has achieved following agreement. One remaining issue is whether on-demand SSB in SCell can be CD-SSB located on sync-raster.

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 agenda 9.5.3, the following conclusion was achieved during RAN1#119 meeting. SSB adaptation in PCell is not supported.

Conclusion
There is no RAN1 consensus to support SSB adaptation in time domain for Rel-19 NES-capable UE's PCell (connected mode)

If on-demand SSB in SCell is CD-SSB located on sync-raster, legacy UEs may successfully access to the NES SCell when CD-SSB is present, the corresponding SCell may be considered as a PCell for another Rel-19 NES-capable UE, which violates the agreement in agenda 9.5.3. Besides, considering the data transmission of legacy UEs relies on L1 measurement for beam tracking and RLM, and L3 measurement for quality evaluation of serving cell, gNB cannot turn off its SSB anymore, resulting in low NES gain. Otherwise, if gNB turns off on-demand SSB, legacy UEs cannot work properly in the NES cell.

Therefore, on-demand SSB in SCell can only be NCD-SSB or not CD-SSB (e.g., SSB not on sync raster). The cell supporting on-demand SSB SCell operation can only be a SCell for both R19 NES-capable UEs and other UEs.

Proposal 1: For a cell supporting on-demand SSB SCell operation, on-demand SSB can not be CD-SSB located on sync-raster.

- **Note that the cell can only be a SCell for both R19 NES-capable UEs and other UEs.**

3. Discussion on on-demand SSB SCell operation

RAN1#116b meeting has identified following four scenarios for on-demand SSB SCell operation:

- Scenario #2: SCell is configured to a UE but before the UE receives SCell activation command (e.g., as defined in TS 38.321)
- Scenario #2A: When UE receives SCell activation command (e.g., as defined in TS 38.321)
- Scenario #3A: After UE receives SCell activation command (e.g., as defined in TS 38.321) until SCell activation is completed
- Scenario #3B: When SCell activation is completed and SCell is activated or after SCell activation is completed and SCell is activated

For the identified scenarios, on-demand SSB can be indicated by gNB at least for Scenario #2 and Case #1/Case #2, Scenario #2A and Case #1/Case #2.

In this section, we discuss indication method for on-demand SSB in Scenario #2 and Scenario #2A, and whether on-demand SSB can be applied to Scenario #3A and Scenario #3B.

3.1 On-demand SSB SCell operation in Scenario #2

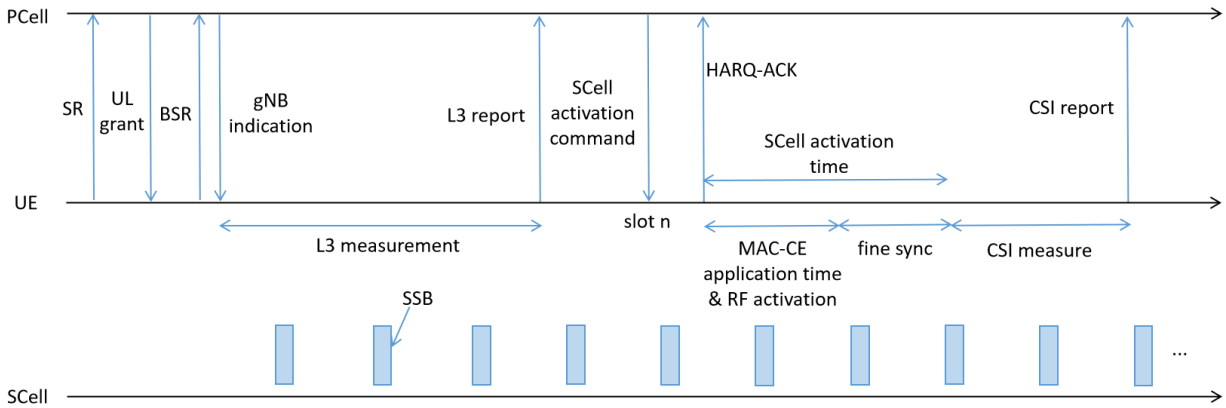

Fig. 1 on-demand SSB triggered by SR/BSR + gNB indication

In Scenario #2, gNB can know the DL traffic status of the UE by itself and the UL traffic status of the UE through SR/BSR procedure. Regarding indication signaling of on-demand SSB, RAN1#118 meeting has agreed that gNB can indicate on-demand SSB transmission in Scenario #2 with MAC CE. Besides, on-demand SSB transmission indicated for one UE

under Scenario#2 may impact procedures like rate matching or UL resource validation of another UE under Scenario#3B. Thus, on-demand SSB transmission indicated for one UE should be known by other UEs. To save signaling overhead, group common DCI is also supported in Scenario #2.

Proposal 2: For on-demand SSB SCell operation in Scenario #2, group common DCI can be considered to indicate on-demand SSB on NES SCell.

3.2 On-demand SSB SCell operation in Scenario #3A and #3B

Since Scenario#2A is supported and the first transmission occasion (i.e. instance A) of on-demand SSB burst can be after UE receives SCell activation signaling and indicated by SCell activation signaling, there is no clear motivation to support Scenario#3A.

Proposal 3: On-demand SSB SCell operation in Scenario #3A is not supported.

For Scenario#3B, considering the traffic load is relatively small in NES SCell, on-demand SSB transmission in a duration is preferred for NES. Then the on-demand SSB activated for scenario 2A is deactivated after SCell activation is completed. After SCell activation completion, it can be up to gNB (e.g. for synchronization or L1 measurement) to trigger on-demand SSB when needed.

On the other hand, considering one SCell may belong to multiple UEs, when the number of UE is comparatively large, there is a high probability that the SCell will be activated (at least for one UE). If on-demand SSB transmission lasts for a long time until SCell deactivation, from NW's perspective, there will be no NES gain without on-demand operation in scenario 3B. Thus, no matter on-demand SSB transmission is one-shot transmission or lasts for a long time, on-demand SSB SCell operation in Scenario#3B shall be supported.

Another issue is whether both UE assumption Case 1 and Case 2 on SSB transmission are applicable under Scenario#3B.

For Case 1, since SSB is not transmitted by default, energy saving gain from both gNB side and UE side can be maximized. UE can perform AGC, synchronization based on TRS (transmitted in large periodicity for NES). If gNB detects requirement on finer T/F synchronization and AGC (e.g. high MCS), gNB can indicate on-demand SSB before data transmission. The delay of these procedure may be long.

For Case 2, since always-on SSB is transmitted (with periodicity larger than 20ms), energy saving gain from both gNB side and UE side will be smaller than Case 1. UE can perform AGC and synchronization based on TRS or always-on SSB, and perform L1 measurement based on always-on SSB. If gNB detects requirement on finer T/F synchronization and AGC, gNB can indicate on-demand SSB before data transmission. The delay of these procedure is shorter compared with Case 1.

Above all, Case 1 and Case 2 have their own advantages and can be both considered in Scenario #3B.

Proposal 4: On-demand SSB SCell operation in Scenario #3B and Case #1/Case #2 can be supported.

Furthermore, considering different UEs may operate in different SCell states, on-demand SSB transmission indicated for one UE in Scenario#2 or 2A may impact rate matching and UL resource validation for another UE in Scenario#3B, especially when on-demand SSB lasts for a long duration. This is because SSB transmission is cell level but indication of on-demand SSB is UE-specific level. Thus, the UE in Scenario#3B does not know about the on-demand SSB transmission triggered for other UEs. To avoid negative impact on UEs in Scenario#3B, gNB should inform UEs in Scenario#3B about the transmission of on-demand SSB for other UEs, and a group common DCI can be considered to indicate on-demand SSB in Scenario #3B with low signaling overhead.

If on-demand SSB for a UE only lasts for a short time, rate matching and UL resource validation issue can be solved via gNB implementation. Under this premise, a DCI for on-demand SSB indication may also be useful to reduce the delay and signaling overhead on resuming data transmission. For instance, a UE-specific DCI can be introduced to indicate on-demand SSB transmission meanwhile scheduling data transmission, so that the UE can perform fine synchronization and AGC right before the data transmission.

Proposal 5: For on-demand SSB SCell operation in Scenario #3B, group common DCI and/or UE-specific DCI can be considered to indicate on-demand SSB on NES SCell.

3.3 Configuration parameters of on-demand SSB

For a cell supporting on-demand SSB SCell operation, RAN1#118 and 118b meeting has agreed at least the following parameters for on-demand SSB can be configured via RRC signaling for Case 1.

- 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
- Sub-carrier spacing of the on-demand SSB
- Physical Cell ID of the on-demand SSB
- Downlink transmit power of on-demand SSB
- Number of SSB bursts

Whether SCS of the on-demand SSB can be absent is still FFS. We think it depends on operating band of SCell. If the operating band supports one SCS, SCS can be absent, otherwise, SCS shall be configurable.

From our understanding, most of above parameters can reuse existing RRC parameters, e.g. *ssbFrequency*, *ssb-PositionsInBurst*, *ssb-PeriodicityServingCell*. New RRC parameters are needed for absolute SFN offset, half frame index, number of SSB bursts of on-demand SSB.

Proposal 6: For Case 1, SCS of the on-demand SSB configured by RRC can be absent or configurable depending on operating band of SCell.

For Case 2, since the frequency location of on-demand SSB is the same as the frequency location of always-on SSB, frequency of on-demand SSB does not need to be configured by RRC. It is up to gNB to configure the same or different time location between on-demand SSB and always-on SSB in RRC signaling. If periodicity or SSB positions within an on-demand SSB burst is absent in RRC signaling, they are the same as that of always-on SSB by default.

The following parameters for on-demand SSB are known to UE, the indication method is still remaining issue.

- Sub-carrier spacing of the on-demand SSB
- Physical Cell ID of the on-demand SSB
- Transmission duration of on-demand SSB
- Downlink transmit power of on-demand SSB

There seems no motivation or benefit to configure different SCS or PCI or downlink transmit power between on-demand SSB and always-on SSB. If SCS or transmit power between on-demand SSB and always-on SSB are different, when on-demand SSB is indicated in Case 2 and scenario 2A, UE needs to perform AGC again based on on-demand SSB, which increases SCell activation delay. On the other hand, gNB cannot transmit two kinds of SSB with the same time location but different SCS or transmit power. Thus the SCS and PCI and downlink transmit power of on-demand SSB are not configured by RRC, they are the same as that of always-on SSB by default.

The number of SSB bursts between time instance A and time instance B can be configured by RRC. The number of SSB bursts can be absent when on-demand SSB is deactivated by MAC-CE.

Regarding the configuration of time domain location of on-demand SSB per on-demand SSB periodicity for Case 2, there remains two alternatives for down-selection.

- Alt A: Same as for Case #1
  - 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.
- 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*)

The motivation of Alt B is to combine always-on SSB and on-demand SSB into SSB with smaller periodicity. For example, always-on SSB with periodicity of 40ms and on-demand SSB with periodicity of 40ms are combined into SSB with periodicity of 20ms. However, this is not suitable for other cases, such as always-on SSB with periodicity of 80ms and on-demand SSB with periodicity of 40ms. Alt A is preferred since it is more flexible and suitable for any offset between always-on SSB and on-demand SSB.

Proposal 7: For Case 2, the following parameters are the same for on-demand SSB and always-on SSB.

- **Sub-carrier spacing of the on-demand SSB**
- **Physical Cell ID of the on-demand SSB**
- **Downlink transmit power of on-demand SSB**

Proposal 8: For Case 2, the following parameters are provided for on-demand SSB configuration by RRC.

- **SSB positions within an on-demand SSB burst**
  - **can be absent**

- **Periodicity of the on-demand SSB**
  - **can be absent**
- **Number of SSB bursts**
  - **can be absent**
- **Absolute SFN offset and half frame index (Alt A of the previous agreement in RAN1#119)**

3.4 determination of time instance A and time instance B

For MAC CE indication, RAN1#118b meeting has following agreement on determination of time instance A. Since time instance A is at least T slots after the slot n where UE receives a MAC CE, time instance A will be after n+T. UE can determine time instance A based on RRC configured SFN offset and half frame index, n and T_min. T can be equal to T_min instead of larger than T_min.

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
  - (Working assumption): T is not less than T_min=$m + 3N_{slot}^{subframe,\mu}$+1 where slot n+m is a slot indicated for PUCCH transmission with HARQ-QCK information when the UE receives MAC CE signaling to indicate on-demand SSB transmission ending in slot n, and $N_{slot}^{subframe,\mu}$ is as defined in current specification.
    - RAN4 to confirm that T_min can be equal to $m + 3N_{slot}^{subframe,\mu}$+1
  - (Working assumption) T=T_min
- Above applies at least for the case where SCell with on demand SSB transmission and cell with signalling transmission have the same numerology.

Proposal 9: The following working assumption is confirmed:

- **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**
  - **(Working assumption): T=T_min**

Regarding to time instance A for RRC indication, UE can search on-demand SSB based on SFN offset and half frame index, there is no need to explicitly define the time position for time instance A.

Proposal 10: The time instance A for RRC indication is not explicitly defined.

RAN1#119 has supported deactivation of on-demand SSB transmission via option 1 and option 2 below. Regarding to the applicable scenario of option 1, on-demand SSB shall not be deactivated in scenario 2/2A since it is still needed for fine synchronization during SCell activation. As our analysis in section 3.2, considering the traffic load is relatively small in NES SCell, on-demand SSB transmission in a duration is preferred for NES. On the other hand, if on-demand SSB transmission lasts for a long time until SCell deactivation, as long as SCell is activated for one UE, there will be no

NES gain. Thus, on-demand SSB shall support deactivate status in scenario 3B. It can be up to gNB to trigger on-demand SSB when needed after SCell activation procedure.

- Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE 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

Option 4 and 4A are not supported. If on-demand SSB transmission does not stop until SCell deactivation, there is no NES gain as long as one UE activates the SCell. Considering the SCell supporting on-demand SSB usually has low traffic load, on-demand SSB transmission in a duration (i.e. option 1 and 2) is preferred.

Proposal 11: For option 1 of deactivation of on-demand SSB, the applicable scenarios are scenario 3B.

Proposal 12: For a cell supporting on-demand SSB SCell operation, option 4 and 4A are not supported to deactivate on-demand SSB transmission.

- **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**

3.5 SSB relation in always-on SSB and OD-SSB

RAN1#119 meeting agreed that the frequency location of on-demand SSB is the same as always-on SSB for the case where always-on SSB is not CD-SSB. The frequency location of on-demand SSB for the case where always-on SSB is CD-SSB needs to be down-selected among 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.
- 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.

If always-on SSB is CD-SSB on a synchronization raster, since the periodicity of always-on SSB is probably larger than 20ms for NES gain, UE may fail to perform initial access after multiple rounds of SSB searching with default periodicity of 20ms. This increases initial access delay of R19 UEs and legacy UEs. Thus, always-on SSB shall not be CD-SSB on a synchronization raster.

There seems no motivation for always-on SSB to be SSB associated with SIB1 and not on a synchronization raster. R19 UEs and legacy UEs will not perform initial access or acquire SIB1 through SSB not on synchronization raster, the transmission of scheduling information of SIB1 in SSB is meaningless. Above all, always-on SSB can only be SSB not associated with SIB1, the frequency location of on-demand SSB and always-on SSB is the same.

Proposal 13: The case where always-on SSB is SSB associated with SIB1 is not supported.

In RAN1 understanding, time location of SSB refers to absolute SFN offset and half frame index, and there is no restriction on time location between always-on SSB and on-demand SSB. gNB has flexibility to configure on-demand SSB to have the same or different time location from always-on SSB.

As the analysis in section 3.3, no matter on-demand SSB and always-on SSB are overlapped in time domain or not, the configuration parameters except *ssb-PositionsInBurst* of two kinds of SSB are the same. The transmitted SSB index of on-demand SSB can be subset of always-on SSB since gNB may transmit on-demand SSB with specific SSB index based on prior information (e.g. UE location).

Proposal 14: The time location between always-on SSB and on-demand SSB can be the same or different.

Proposal 15: SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

3.6 L1 measurement of on-demand SSB

For Case 1, L1 measurement relies on on-demand SSB. Since on-demand SSB will be deactivated by MAC-CE or after transmission of N periodicity, on-demand SSB is transmitted within a duration. Only semi-persistent and aperiodic CSI reporting can apply for L1 measurement of on-demand SSB. The previous agreement on reporting type of L1 measurement of on-demand SSB needs update.

Proposal 16: Update the previous RAN1 agreement as follows.
At least support L1 measurement based on on-demand SSB

- **For L1 measurement based on on-demand SSB, ~~periodic,~~ semi-persistent, ~~,~~and aperiodic~~,~~ L1 measurement reports based on existing CSI framework are supported.**
  - **FFS on potential enhancements of CSI report configuration and/or triggering/activation mechanisms for L1 measurement based on on-demand SSB**
  - **The support of LTM is a separate discussion point**

For Case 2, one discussion point is when both always-on SSB and on-demand SSB are transmitted, whether L1 measurement is based on always-on SSB or on-demand SSB or both always-on SSB and on-demand SSB. In our understanding, UE measures on-demand SSB is a baseline from the reasons below:

- Comparing with measuring always-on SSB, L1 measurement based on on-demand SSB has lower measurement latency. UE can report measurement results timely with smaller reporting periodicity.
- Comparing with measuring both always-on SSB and on-demand SSB, since always-on SSB and on-demand SSB may have different SFN offset, it is difficult to determine the measurement requirements in RAN4 with the combination of measurement results of different SSB.
- Furthermore, it can up to gNB implementation to configure time location of on-demand SSB fully overlapping with always-on SSB to reduce the NW power consumption.

Proposal 17: For Case 2, when both always-on SSB and on-demand SSB are transmitted, L1 measurement is based on on-demand SSB.

Regarding to CSI report configuration method, gNB has flexibility to configure CSI report configuration associated with one or both of always-on SSB and on-demand SSB, both of following two options can be considered.

- 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

With option 1, although CSI report configuration is associated with two kinds of SSB, UE only measures on-demand SSB when on-demand SSB is indicated and measures always-on SSB when on-demand SSB is deactivated. There can be two alternatives of the association of CSI report configuration and SSB:

- Alternative 1 is configuring separate resource set for different SSB, SSB index of always-on SSB and on-demand SSB may be different. Separate reporting periodicity is configured for different SSB to adapt to the variation of SSB transmission periodicity.
- Alternative 2 is configuring one resource set, and separate reporting periodicity is configured for different SSB to adapt to the variation of SSB transmission periodicity. When on-demand SSB is indicated, SSB index in this resource set is associated with on-demand SSB, small reporting periodicity is adopted accordingly for timely and accurate measurement report. When on-demand SSB is deactivated, SSB index in this resource set is associated with always-on SSB, large reporting periodicity is adopted.

With option 2, if one periodic/semi-persistent/aperiodic CSI-ReportConfig 1 is associated with always-on SSB, another semi-persistent/aperiodic CSI-ReportConfig 2 is associated with on-demand SSB, gNB can activate/deactivate CSI-ReportConfig 2 depending on the indication/deactivation of on-demand SSB. The CSI calculation of measurement results of two SSB will not combine.

Proposal 18: For Case 2, both of the following options are considered for 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**

Proposal 19: For Case 2, with CSI report configuration Option 1, two alternatives are considered for the association of CSI report configuration and SSB.

- **Alt 1: separate resource set are configured for always-on SSB and on-demand SSB, different resource set is associated with different reporting periodicity**

- **Alt 2: one resource set is associated with always-on SSB or on-demand SSB implicitly, different SSB is associated with different reporting periodicity**

4. Conclusion

In this contribution, we discussed the applicable scenario, indication method and L1 measurement of on-demand SSB in SCell for connected UEs, and the following proposals are made.

Proposal 1: For a cell supporting on-demand SSB SCell operation, on-demand SSB can not be CD-SSB located on sync-raster.

- **Note that the cell can only be a SCell for both R19 NES-capable UEs and other UEs.**

Proposal 2: For on-demand SSB SCell operation in Scenario #2, group common DCI can be considered to indicate on-demand SSB on NES SCell.

Proposal 3: On-demand SSB SCell operation in Scenario #3A is not supported.

Proposal 4: On-demand SSB SCell operation in Scenario #3B and Case #1/Case #2 can be supported.

Proposal 5: For on-demand SSB SCell operation in Scenario #3B, group common DCI and/or UE-specific DCI can be considered to indicate on-demand SSB on NES SCell.

Proposal 6: For Case 1, SCS of the on-demand SSB configured by RRC can be absent or configurable depending on operating band of SCell.

Proposal 7: For Case 2, the following parameters are the same for on-demand SSB and always-on SSB.

- **Sub-carrier spacing of the on-demand SSB**
- **Physical Cell ID of the on-demand SSB**
- **Downlink transmit power of on-demand SSB**

Proposal 8: For Case 2, the following parameters are provided for on-demand SSB configuration by RRC.

- **SSB positions within an on-demand SSB burst**
  - **can be absent**
- **Periodicity of the on-demand SSB**
  - **can be absent**
- **Number of SSB bursts**
  - **can be absent**
- **Absolute SFN offset and half frame index (Alt A of the previous agreement in RAN1#119)**

Proposal 9: The following working assumption is confirmed:

- **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**
  - **(Working assumption): T=T_min**

Proposal 10: The time instance A for RRC indication is not explicitly defined.

Proposal 11: For option 1 of deactivation of on-demand SSB, the applicable scenarios are scenario 3A and 3B.

Proposal 12: For a cell supporting on-demand SSB SCell operation, option 4 and 4A are not supported to deactivate on-demand SSB transmission.

- **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**

Proposal 13: The case where always-on SSB is SSB associated with SIB1 is not supported.

Proposal 14: The time location between always-on SSB and on-demand SSB can be the same or different.

Proposal 15: SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst.

Proposal 16: Update the previous RAN1 agreement as follows.
At least support L1 measurement based on on-demand SSB

- **For L1 measurement based on on-demand SSB, ~~periodic,~~ semi-persistent, ~~,~~and aperiodic~~,~~ L1 measurement reports based on existing CSI framework are supported.**
  - **FFS on potential enhancements of CSI report configuration and/or triggering/activation mechanisms for L1 measurement based on on-demand SSB**
  - **The support of LTM is a separate discussion point**

Proposal 17: For Case 2, when both always-on SSB and on-demand SSB are transmitted, L1 measurement is based on on-demand SSB.

Proposal 18: For Case 2, both of the following options are considered for 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**

Proposal 19: For Case 2, with CSI report configuration Option 1, two alternatives are considered for the association of CSI report configuration and SSB.

- **Alt 1: separate resource set are configured for always-on SSB and on-demand SSB, different resource set is associated with different reporting periodicity**
- **Alt 2: one resource set is associated with always-on SSB or on-demand SSB implicitly, different SSB is associated with different reporting periodicity**

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5. References

[1] Chair notes RAN1#119 eom0, RAN1#118b, Hefei, China, October 14th – 18th, 2024.