

Athens, Greece, February 17th – 21st, 2025**Agenda Item: 9.5.1****Source: Panasonic****Title: Discussion on on-demand SSB SCell operation****Document for: Discussion/Decision**

1 Introduction

In the previous three meeting, the agreements listed in Appendix were achieved for on-demand SSB SCell operation [1] [2][3][4][5].

In this contribution, we further share our views on the targeted scenarios and corresponding on-demand SSB SCell operation.

2 Discussion

2.1 On-demand SSB triggering and transmission timing

In the RAN1#116bis meeting, following agreement was achieved, regarding the on-demand SSB triggering timing

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.
- 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.

The already supported Scenario 2 and 2A apply to the triggering/indication timing of the on-demand before and when UE receives the SCell activation command. On the other hand, it is still FFS whether the triggering/indication timing can be after UE receives SCell activation command (Scenario #3A and #3B). Our view is, when on-demand SSB is triggered should be decided by network and after it is triggered, when to indicate UE the availability of the SSB is also up to network implementation, especially for Case #2, where always-on SSB is available. This keeps the flexibility for network to achieve energy saving, due to following reasons and use cases:

- As an SCell could be configured and/or activated for multiple UEs, for different UEs, network may indicate the on-demand SSB availability in different timing occasions, depending on the control resource status and the concrete signaling design, i.e., RRC, MAC CE or group-common/UE specific DCI.
- Even after the SCell is activated, on-demand SSB may also be further triggered and indicated by network, even if the “always-on” SSB in Case 2 is already available.
- For an SCell with SSB-less operation, network may also trigger/indicate the on-demand SSB to further improve the connectivity quality, if the reference cell SSB is no longer reliable or available due to mobility reason or the reference cell is deactivated or turned off by the network. It is noted that this may happen and should not be regarded as corner case, as the reference cell for SSB-less operation can either be a PCell or SCell.

Given all the reasons and analysis above:

Proposal 1: On-demand SSB triggering timing is up to network implementation irrespective of UE situation. Therefore, scenario #3A/3B and Case 1/2 should be also supported for on-demand SSB.

2.2 Compatibility of the on-demand SSB SCell operation

In this section, we discuss the potential impact to the compatibility and coexistence with legacy UEs by introducing the on-demand SSB feature. Below agreement from RAN1#118 and #119 meeting was achieved which is related to this topic:

Agreement from RAN1 #118 meeting

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

Agreement RAN1#119

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.

As the usage of a serving cell frequency is up to network implementation, when an SCell frequency is configured to a Rel.19 UE as an SCell operating on-demand SSB, it may also be configured to a legacy UE not supporting such feature as a PCell or SCell. Legacy always-on SSB could serve all the functions (cell identification, RRM measurement and t/f sync), while on-demand SSB can be used for t/f sync before traffic (both co-located and non-co-located case) or all the functions (e.g., for co-located case).

- If legacy UE is served in on-demand SSB SCell, the SSB ON/OFF for legacy UEs may be controlled by the MAC-CE based SCell activation/deactivation procedure. Or this SCell can be configured with SSB-less SCell operation. While for Rel.19 UEs, more efficient signaling and procedure is also worth to utilize. We see such deployments have energy saving and signaling overhead merits. However, if such on-demand SSB is cell defining SSB, in order to avoid impact to legacy UEs, network needs to carefully handle the already camped UEs and RRC connected UEs when this on-demand SSB transits between ON and OFF. Another possible operation is MIB indicates this cell is barred for all UEs. This can prevent legacy UEs to camp/connect the cell but UE power consumption would be increased because to detect the barred cell.
- Therefore, we stick only to on-demand SSB which is not on synchronization raster and/or not CD SSB, which makes the design and discussion simpler.

Proposal 2: OD-SSB for CD-SSB located on sync-raster is not supported.

Besides legacy UEs, new Rel.19 UEs may also use the cell with OD-SSB operation as PCell or a cell to camp. In such case, network should reasonably deploy the always-on SSB as a CD-SSB. Then to avoid confusion to legacy UEs, we support the Alt 1 in the above RAN1#119 meeting agreement.

Proposal 3: To agree on 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.

When always-on SSB is not on synchronization raster, there is no impact to legacy UEs and the frequency location of OD-SSB should be up to network configuration, which facilitates flexibility for network resource allocation and energy saving operation. Therefore, we support Alt A:

Proposal 4: To agree on 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 On-demand SSB based L1/L3 measurements

On the measurements based on on-demand SSB, below agreement was achieved.

Agreement RAN1#116bis

- For a cell supporting on-demand SSB SCell operation,
 - L1 and/or L3 measurement based on on-demand SSB is supported for the cell.
 - FFS further details on L1 and/or L3 measurement

Agreement RAN1#118

- 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**

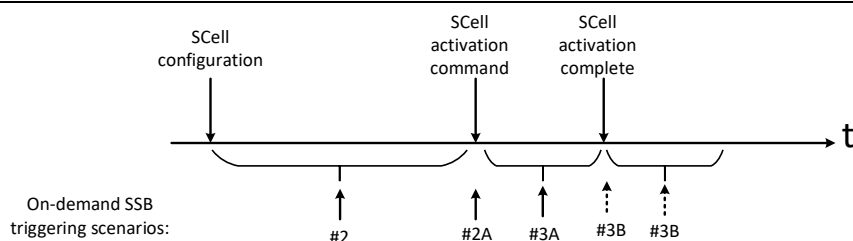


Figure 1. The on-demand SSB triggering scenarios explanation

Considering the CA operation based on on-demand SSB, below are our views for the on-demand SSB based measurement:

- On L3 measurement based on on-demand SSB, as shown in Figure.1, for Scenario #2, it can be reported to gNB to assist on determining whether the SCell has sufficiently good channel

condition to activate for traffic scheduling. Even after SCell activation, i.e., Scenario #3B, L3 measurement based on on-demand SSB may also be reported to gNB for RRM purpose. Based on the measurement results, SCell deactivation and on-demand SSB ON/OFF can be facilitated.

Proposal 5: L3 measurement based on on-demand SSB should be supported at least for Scenario #2. To facilitate the SCell deactivation and on-demand SSB ON/OFF, other scenarios can also be supported.

- On L1 measurement based on on-demand SSB, as it is mainly used for CSI measurement for traffic scheduling, it should be supported at least for Scenario 2A, 3A and 3B, i.e., after the SCell is activated. Such L1 measurement is only when on-demand SSB is ON. Before SCell activation(Scenario 2), it should be clarified whether L1 measurement is supported for LTM and what type of P/SP/AP report is supported.

Proposal 6: L1 measurement when on-demand SSB is ON should be supported at least for Scenario 2A, 3A and 3B i.e., after the SCell is activated. On Scenario 2, further clarification is needed on whether to support on-demand SSB based L1 measurement for LTM and the supported type of CSI.

On the CSI framework for L1 measurement based on on-demand SSB, we think the legacy principle should also apply that the report should be equally or more dynamic than the reference resource. It means UE is not required to support CSI reporting when on demand SSB is OFF. As so far, the on-demand SSB can be RRC, MAC CE or group common DCI triggered, the relation can be summarized in the Table.1 below.

Table.1 CSI framework for L1 measurement based on on-demand SSB

on-demand SSB triggering/indication	Periodic CSI report	Semi-persistent CSI report	Aperiodic CSI report
RRC based	Support	Support	Support
MAC CE based	Not supported as first preference. If supported, enhancement should minimize the specification impact	Support	Support
Group common DCI	Not supported	Supported. Network ensures on-demand SSB is available when SP-CSI report is activated.	Support

(discussed in section 2.4)			
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Proposal 7: For RRC triggered/indicated on-demand SSB, the periodic, semi-persistent and aperiodic CSI report should be supported with current CSI mechanism.

Proposal 8: For MAC CE triggered/indicated on-demand SSB, semi-persistent and aperiodic CSI report should be supported with enhancement that on-demand SSB is expected to be available when CSI report is active. On periodic CSI report, although our first preference is not to support, we can be flexible if the specification impact can be minimized.

Proposal 9: For group common DCI triggered/indicated on-demand SSB, only semi-persistent and aperiodic CSI report should be supported.

On time/frequency synchronization based on on-demand SSB, it should be mainly performed in Scenario 3B. After SCell activation is complete, UE may use the on-demand SSB for time/frequency synchronization when receiving PDCCH and PDSCH for traffic scheduling, e.g., the TCI state reference resource can be on-demand SSB.

Proposal 10: For time/frequency synchronization and TCI state using on-demand SSB as reference resource, only Scenario #3B is supported.

2.4 On-demand SSB transmission signalling design

In the RAN1#118bis meeting, regarding the on-demand SSB operation triggered by gNB, below agreements were achieved for transmission timing design.

Agreement from RAN1#118 meeting

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 $T_{\min} = m + 3N_{\text{slot}}^{\text{subframe}, \mu} + 1$ 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 $N_{\text{slot}}^{\text{subframe}, \mu}$ is as defined in current specification.
 - RAN4 to confirm that T_{\min} can be equal to $m + 3N_{\text{slot}}^{\text{subframe}, \mu} + 1$
- (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.

Regarding texts of working assumption:

- For the second and third working assumption, the reason is some companies think gNB need different time offset requirements for T_{\min} , for signaling indicating SCell activation, on-demand SSB triggering and SCell activation + on-demand SSB triggering. Whether different requirements for different cases are necessary further needs RAN4 confirmation. However, we think a reasonable gNB operation could make sure the on-demand SSB and/or SCell activation is ready before the T_{\min} latency, or even gNB can indicate after the preparation is ready. Therefore, we think the second and third working assumptions should also be confirmed without any issue.

Proposal 11: The texts of working assumptions in the above agreement should be confirmed.

Our view on the on-demand SSB transmission period is:

- On-demand SSB can be optionally configured by RRC with a validity period.
 - Once the UE receives the on-demand SSB triggering indication, UE may assume on-demand SSB is available after an application delay, which is T, and until the RRC configured validity period expires.
 - If validity period is not configured, on-demand SSB is default to be valid until gNB indicates to turn OFF the SSB
- On-demand SSB triggering indication can be before, at the same time with or after the SCell activation without limitation.

Proposal 12: On-demand SSB triggering indication can be before, at the same time with or after the SCell activation without limitation. The validity period can be RRC configurable. If not configured, on-demand SSB is default to be valid until gNB indicates to turn OFF the SSB.

In the previous meetings, RRC and MAC CE based signaling have been agreed to indicate on-demand SSB activation and deactivation.

Agreement from RAN1 #116bis meeting

- 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 signalings are applicable

Agreement from RAN1#119 meeting

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

- On whether to support DCI based on-demand SSB triggering, we prefer to support group common DCI for more dynamic adaptation as the other NES functionalities. Below two options can be considered to support group common DCI by RRC configuration.
 - Option 1: RRC may configure to utilize separate bits in group common DCI for each SCell.

SCell #0	SCell #1	...
1 bit SSB on/off	1 bit SSB on/off	1 bit SSB on/off

- Option 2: RRC may configure joint indication in group common DCI for each SCell group.

SCell group#0	SCell group#1	...
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1 bit for SSB on/off	1 bit for SSB on/off	1 bit for SSB on/off
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Proposal 13: In addition to RRC and MAC CE based SSB triggering, DCI-based on-demand SSB triggering and deactivation indication is supported. By RRC configuration, separate bits for SSB ON/OFF of each SCell and joint indication for each SCell group can be supported.

Regarding on-demand SSB transmission deactivation, following agreement was achieved in the previous meeting.

Agreement from RAN1#118 meeting

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

Our views are:

- Option 1 (MAC CE-based) and Option 1A (RRC-based) should be supported, which follow the design of already supported on-demand SSB triggering method.
- We are open to discuss Option 2 or 3, which is aligned with Proposal 12.
- Option 4 is contradictory with what RAN2 has just agreed in the RAN2#127bis meeting as below. RAN2 assumes separated MAC CE for SCell activation/deactivation and OD-SSB indication for scenario 2A. If option 4 is supported in RAN1, when UE receives MAC CE for SCell deactivation, implicitly OD-SSB is deactivated. To support this implicit behaviour, RAN1 needs to consider conditions to be applied. As discussed on Option 4A below, there is the case that SCell is deactivated but OD-SSB is still transmitted. From RAN1 perspective, we

also do not see any merits to support implicit MAC CE as Option 4 and explicit MAC CE as Option 1 is enough.

Agreements on OD-SSB SCell

1. No need to restrict the OD-SSB activation/deactivation state indication in RRC to initial configuration. No special specification effort is required.
 2. Don't introduce further new MAC CE that combines SCell activation/deactivation and OD-SSB indication for scenario 2A.
 3. NW should be able to send OD-SSB indication for multiple SCells simultaneously by a MAC CE.
- Option 4A and 5 limit the availability of on-demand SSB, which is bundled with the SCell activation state. In our view, it is not necessary operation, as on-demand SSB can be used for at L3 measurement without being limited by the SCell activation/deactivation state. gNB can flexibly control the on-demand SSB ON/OFF without such limitation.
 - We propose Option 6 via group-common DCI, which provides more flexibility and NES gain.

Proposal 14: For on-demand SSB transmission deactivation, Option 1 (MAC CE-based), 1A (RRC-based) and Option 6 (DCI-based) should be supported. We are also open to discuss Option 2 and 3 to define and configure a validity period/duration for on-demand SSB.

On the configuration of time domain location of OD-SSB, below agreement was achieved.

Agreement from RAN1#119 meeting

- 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 $(\text{SFN index} * 10) \bmod (\text{OD-SSB periodicity}) = 0$
 - 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*)

In our view, for both cases, the scheme agreed of Case#1 is sufficient to configure time domain location of OD-SSB. It keeps reasonable network configuration flexibility and simple specification impact.

The controversial part of Case #2 Alt B is whether/how the combination of always-on and OD-SSB yields a sufficiently simple time domain pattern for UE to measure, for example, both sets of SSBs are with periodicity of 40ms and are offset by 20ms, which generates a pattern with periodicity of 20ms. In our view, such enhancement is essentially to just support one set of SSB with different time domain patterns but not fitting to the framework of OD-SSB. It should belong to the feature of 9.5.3.

Proposal 15: For both Case 1(i.e., No always-on SSB on the cell) and Case 2(i.e., Always-on SSB is periodically transmitted on the cell), support to configure time domain location of OD-SSB per OD-SSB period by RRC 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 $(\text{SFN index} * 10) \bmod (\text{OD-SSB periodicity}) = 0$
- 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.

2.5 On two sets of SSBs

Adaptation of SSB periodicities

In the RAN1#118 meeting, below agreement was achieved.

Agreement RAN1#118

For a cell supporting on-demand SSB SCell operation, at least 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.

- Periodicity of the on-demand SSB
- FFS: Any other relevant parameters

For the on-demand SSB design, time domain adaptation should not be the focus in this agenda. Any more detailed and flexible design for SSB adaptation, for example any other relevant parameter adaptation, should be discussed and specified in the 9.5.3.

Therefore,

Proposal 16: 9.5.1 only supports that periodicity of the on-demand SSB can be indicated.

Always-on and on-demand SSB coexistence

For Case 2, where the always-on SSB is periodically transmitted on SCell, after on-demand SSB is indicated/triggered, there will be two sets of SSB being coexisting and transmitted. More specifically, below two cases may happen.

- **Always-on SSB and on-demand SSB are transmitted on the same SCell.** In this case, it should be clarified that whether these two set of SSB are QCLeD or not. If they are QCLeD, the L1/L3 measurement accuracy and t/f synchronization performance can be further enhanced by using both sets of SSB. Also, the UE power consumption for measurement can be reduced as UE can choose either of SSB suitable for UE power saving timing, which can minimize the wake-up time required by SSB reception. Below agreement was achieved in the previous meeting for L1 measurement for Case 2. On the FFS bullet, our view is it can be up to gNB configuration where always-on and on-demand SSB are QCLeD or not.
 - When always-on and on-demand SSB are QCLeD, either Option 1 or 2 can be configured. But we see the merit of Option 1 to improve the measurement accuracy.
 - When always-on and on-demand SSB are not QCLeD, e.g, always-on SSB are transmitted with wider beams and on-demand SSB are transmitted with narrower beams, Option 2 is clearer design for separate report of CSI measured with different set of SSBs

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

Therefore,

Proposal 17: For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), both options are supported:

- When always-on and on-demand SSB have same beams, Option 1 should be supported that a CSI report configuration is associated with both of on-demand SSB and always-on SSB
- When always-on and on-demand SSB have different beams, Option 2 should be supported that a CSI report configuration is associated with one of always-on SSB and on-demand SSB

- **Always on SSB is already transmitted on the reference cell of a SCell for SSB-less operation and on-demand SSB is then triggered and transmitted in the SCell.** Then for a UE performing SSB-less operation, two possible behaviours can be discussed:
 - UE stops measuring the SSB of the reference cell and only measuring the on-demand SSB triggered in the SCell. It is equivalent to switch the reference cell back to the SCell itself. Or
 - UE measures either or both set of SSBs of the reference cell or/and the SCell as up to UE implementation. Then in this case, it should also be clarified that whether these two sets of SSBs are QCLed or not. If they are QCLed, the merits of the above case of two sets of SSBs within a same SCell also apply here.

Proposal 18: When always-on SSB is transmitted on the reference cell of a SCell for SSB-less operation and on-demand SSB is then triggered and transmitted in the SCell, the relation and the QCL of two sets of SSBs should be further discussed and clarified.

On multiplexing of always-on and on-demand SSB

In the previous meeting, below agreement was achieved regarding the multiplexing of always-on and on-demand SSB.

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

In our view, above multiplexing cases have overlapping. For discussion with clearer and separate cases:

- Case A: always-on SSB and on-demand SSB may use the same time resource but different frequency resource
- Case B: always-on SSB and on-demand SSB may use the different time resource but the same frequency resource
- Case C: always-on SSB and on-demand SSB uses the different time resource and the different frequency resource

In general, Case B and Case C, which corresponds to Mux-Case #1, should at least be supported, as no issue identified from UE side and gNB resource allocation flexibility can be achieved.

For Case A, gNB implementation may be restricted for the case of analogue beamforming, although it would be possibly supported for the digital beamforming case with some additional complexity. Furthermore, from UE side, simultaneous reception of the two sets of SSB can be complex. By proper configuration of periodicity and offset, always-on SSB and on-demand SSB can be guaranteed in different time occasions. Therefore,

Proposal 19: At least Mux-Case #1 (No time-domain overlap between always-on SSB and on-demand SSB) should be supported.

3 Conclusion

Based on the discussion, the following proposals are highlighted:

Proposal 1: On-demand SSB triggering timing is up to network implementation irrespective of UE situation. Therefore, scenario #3A/3B and Case 1/2 should be also supported for on-demand SSB.

Proposal 2: OD-SSB for CD-SSB located on sync-raster is not supported.

Proposal 3: To agree on 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 4: To agree on 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: L3 measurement based on on-demand SSB should be supported at least for Scenario #2. To facilitate the SCell deactivation and on-demand SSB ON/OFF, other scenarios can also be supported.

Proposal 6: L1 measurement when on-demand SSB is ON should be supported at least for Scenario 2A, 3A and 3B i.e., after the SCell is activated. On Scenario 2, further clarification is needed on whether to support on-demand SSB based L1 measurement for LTM and the supported type of CSI.

Proposal 7: For RRC triggered/indicated on-demand SSB, the periodic, semi-persistent and aperiodic CSI report should be supported with current CSI mechanism.

Proposal 8: For MAC CE triggered/indicated on-demand SSB, semi-persistent and aperiodic CSI report should be supported with enhancement that on-demand SSB is expected to be available when CSI report is active. On periodic CSI report, although our first preference is not to support, we can be flexible if the specification impact can be minimized.

Proposal 9: For group common DCI triggered/indicated on-demand SSB, only semi-persistent and aperiodic CSI report should be supported.

Proposal 10: For time/frequency synchronization and TCI state using on-demand SSB as reference resource, only Scenario #3B is supported.

Proposal 11: The **texts of working assumptions** in the above agreement (from RAN1#118 meeting) should be confirmed.

Proposal 12: On-demand SSB triggering indication can be before, at the same time with or after the SCell activation without limitation. The validity period can be RRC configurable. If not configured, on-demand SSB is default to be valid until gNB indicates to turn OFF the SSB.

Proposal 13: In addition to RRC and MAC CE based SSB triggering, DCI-based on-demand SSB triggering and deactivation indication is supported. By RRC configuration, separate bits for SSB ON/OFF of each SCell and joint indication for each SCell group can be supported.

Proposal 14: For on-demand SSB transmission deactivation, Option 1 (MAC CE-based), 1A (RRC-based) and Option 6 (DCI-based) should be supported. We are also open to discuss Option 2 and 3 to define and configure a validity period/duration for on-demand SSB.

Proposal 15: For both Case 1(i.e., No always-on SSB on the cell) and Case 2(i.e., Always-on SSB is periodically transmitted on the cell), support to configure time domain location of OD-SSB per OD-SSB period by RRC 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 $(\text{SFN index} * 10) \bmod (\text{OD-SSB periodicity}) = 0$
- 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.

Proposal 16: 9.5.1 only supports that periodicity of the on-demand SSB can be indicated.

Proposal 17: For a cell supporting on-demand SSB SCell operation and for Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), both options are supported:

- When always-on and on-demand SSB have same beams, Option 1 should be supported that a CSI report configuration is associated with both of on-demand SSB and always-on SSB
- When always-on and on-demand SSB have different beams, Option 2 should be supported that a CSI report configuration is associated with one of always-on SSB and on-demand SSB

Proposal 18: When always-on SSB is transmitted on the reference cell of a SCell for SSB-less operation and on-demand SSB is then triggered and transmitted in the SCell, the relation and the QCL of two sets of SSBs should be further discussed and clarified.

Proposal 19: At least Mux-Case #1 (No time-domain overlap between always-on SSB and on-demand SSB) should be supported.

4 Reference

- [1] 3GPP RAN1 #116bis Chairman's notes
- [2] 3GPP RAN1 #117 Chairman's notes
- [3] 3GPP RAN1 #118 Chairman's notes
- [4] 3GPP RAN1 #118bis Chairman's notes
- [5] 3GPP RAN1 #119 Chairman's notes

5 Appendix

Agreements from RAN1#116bis meeting

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.
- 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.

Agreement

- For a cell supporting on-demand SSB SCell operation,
 - Note: It is up to gNB implementation whether always-on SSB (if transmitted) on the cell is cell-defining SSB or not.
 - For on-demand SSB on the cell, downselect between the following alternatives
 - Alt-1: It is up to gNB implementation whether on-demand SSB is cell-defining SSB or not.
 - Alt-2: On-demand SSB is limited to non-cell-defining SSB.
 - FFS: Further limitations to on-demand SSB

Agreement

- For a cell supporting on-demand SSB SCell operation,
 - L1 and/or L3 measurement based on on-demand SSB is supported for the cell.
 - FFS further details on L1 and/or L3 measurement

Agreement

The following agreement from RAN1#116 is modified (in red)

- For SSB burst(s) ~~triggered~~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)

Agreement

For a cell supporting on-demand SSB SCell operation, further study the following options.

- Option 1: Separate signaling between legacy/existing signaling (e.g., RRC, MAC CE) providing SCell activation/deactivation and signaling providing On-demand SSB transmission indication.
- Option 2: A single signaling in which both SCell activation/deactivation and On-demand SSB transmission indication are provided.
 - FFS: Details of the signaling
- Other options are not precluded.
- FFS: Details on On-demand SSB transmission indication

Agreements from RAN1#117 meeting

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 signalings are applicable

Agreement

- 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

- 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

Agreement

For SSB burst(s) indicated by on-demand SSB SCell operation via 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 slot boundary of] the first SSB time domain position [of actually transmitted on-demand SSB burst] which is T [slots or symbols] after the [slot or symbol] 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.
- FFS: Details of the value of T (≥ 0) including possibility of T comprising of multiple components
- Note: The value of T is not less than existing timeline required for UE's MAC CE processing for SCell activation
- FFS: Whether the value of T is predefined or indicated/configured by gNB
- FFS: Details of "the [slot or symbol] where UE receives a signalling from gNB" or "the [slot or symbol] where UE transmits HARQ-ACK corresponding to a signalling from gNB to trigger on-demand SSB"

Above applies at least for the case where SCell with on demand SSB transmission and cell with signalling transmission have the same numerology.

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

Agreements from RAN1#118 meeting

Agreement

- 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

Agreement

For a cell supporting on-demand SSB SCell operation, at least 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.

- Periodicity of the on-demand SSB
- FFS: Any other relevant parameters

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

Agreement

Support L3 measurement based on on-demand SSB

- Further work on L3 measurement is up to RAN2/RAN4

Agreement

LS to RAN2 for on-demand SSB SCell operation is agreed. Final LS in R1-2407438.

Agreement

The previous RAN1 agreement made in RAN1#117 is **revised** as follows.

- For SSB burst(s) indicated by on-demand SSB SCell operation via 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 on-demand SSB burst ~~[the slot boundary of] the first SSB time domain position [of actually transmitted on-demand SSB burst]~~ which is **at least** T [slots ~~or symbols~~] after the ~~[slot or symbol]~~ 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.
 - ~~○ FFS: Details of the value of T (≥ 0) including possibility of T comprising of multiple components~~
 - 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 $T_{\min} = m + 3N_{\text{slot}}^{\text{subframe}, I?} + 1$ 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 $N_{\text{slot}}^{\text{subframe}, I?}$ is as defined in current specification.
 - RAN4 to confirm that T_{\min} can be equal to $m + 3N_{\text{slot}}^{\text{subframe}, I?} + 1$
 - ~~○ FFS: Whether the value of T is predefined or indicated/configured by gNB~~
 - **(Working assumption)** $T = T_{\min}$
 - ~~○ FFS: Details of "the [slot or symbol] where UE receives a signalling from gNB" or "the [slot or symbol] where UE transmits HARQ-ACK corresponding to a signalling from gNB to trigger on-demand SSB"~~
- Above applies at least for the case where SCell with on demand SSB transmission and cell with signalling transmission have the same numerology.

Agreement

LS on timeline for On-demand SSB operation on SCell is agreed in **R1-2407565**.

Agreements from RAN1#118bis meeting

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

Agreement

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

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

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 $T_{\min} = m + 3N_{\text{slot}}^{\text{subframe}, \mu} + 1$ 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 $N_{\text{slot}}^{\text{subframe}, \mu}$ is as defined in current specification.
 - RAN4 to confirm that T_{\min} can be equal to $m + 3N_{\text{slot}}^{\text{subframe}, \mu} + 1$
 - (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.

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

Agreements from RAN1#119 meeting

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 $(\text{SFN index} * 10) \bmod (\text{OD-SSB periodicity}) = 0$
 - 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