3GPP TSG RAN WG1 Meeting #120 **R1-2500913**
Athens, Greece, February 17th – 21st, 2025

Source: **ETRI**
Title: **Discussion on On-demand SSB SCell operation**
Agenda item: **9.5.1**
Document for: **Discussion/Decision**

1 Introduction

In the last RAN1#119 meeting, the following agreements were made for on-demand SSB SCell operation [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. RAN1 is discussing whether to introduce other periodicity value(s) for on-demand SSB.
- The periodicity of on-demand SSB can be configured separately from the periodicity of always-on SSB.
- RAN1 is discussing what is the relation between periodicity of always-on SSB and periodicity of on-demand SSB and it has been identified that the main use case is that the periodicity of on-demand SSB is equal to or smaller than that of always-on SSB.

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
- 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

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 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

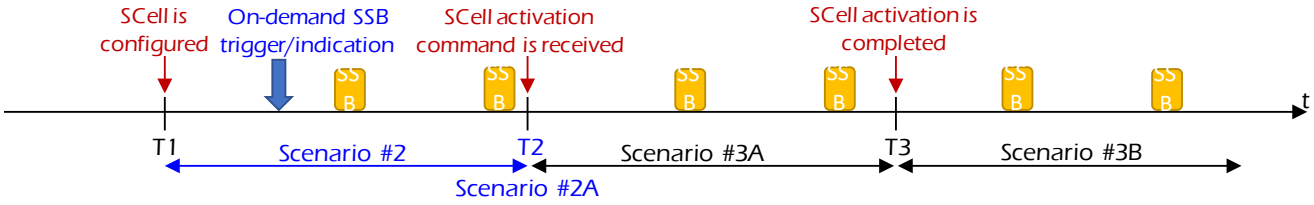
Based on the above agreements, we introduce our views on on-demand SSB SCell operation in this contribution.

2 On-demand SSB SCell operation

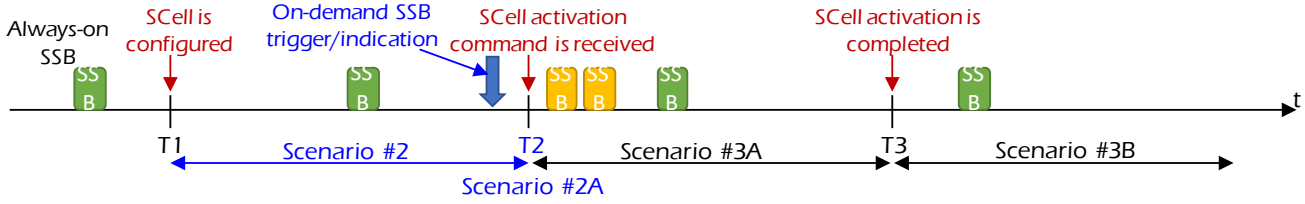
According to the WID, it is necessary to specify procedures and signaling method(s) to support on-demand SSB SCell operation for UEs in connected mode configured with CA [2]. For supporting on-demand SSB SCell operation, triggering method(s) is necessary to initiate on-demand SSB transmission. In addition to the triggering method(s), additional information could be reported from a UE in order to improve the efficiency of on-demand SSB transmission with a proper configuration. If the on-demand SSB transmission starts once and continues thereafter, the network energy saving gain will be marginal. For further network energy saving gain, procedure(s) and method(s) to stop and/or reconfigure SSB transmission would be necessary. In the following subsections, we introduce further views on each issue.

2.1 Scenarios for on-demand SSB SCell operation

In RAN1#116bis meeting, four combinations of scenarios and cases were identified and agreed for on-demand SSB SCell operation [3] as shown in Figure 1. In our opinion, all combinations can be considered for future discussion.



(a) Scenario #2/#2A and Case #1



(b) Scenario #2/#2A and Case #2

Figure 1. Agreed combinations of scenarios and cases for on-demand SSB operation

In case of Scenario #3A, SSB can be used for several purposes such as cell search, AGC, time/frequency synchronization, CSI measurements and so on after receiving SCell activation command. Therefore, on-demand SSB can be triggered for this scenario. However, when or after completion of SCell activation i.e., Scenario #3B, RRM/RLM/BFD/CSI measurements can be performed using CSI-RS and/or always-on SSB if supported. In addition, if on-demand SSB is transmitted continuously after the completion of SCell activation, it cannot be considered as on-demand SSB anymore and the network energy saving gain would be marginal. Therefore, Scenario #3B should be precluded from the candidate on-demand SSB scenarios for network energy saving.

Proposal 1: In addition to previous agreed scenarios, it is proposed to consider #3A for further discussion for on-demand SSB SCell operation and preclude Scenario #3B.

2.2 Time/Frequency/Spatial relation between always-on SSB and on-demand SSB

Regarding whether on-demand SSB is cell-defining or not, it was agreed that on-demand SSB on the cell is not located on synchronization raster and/or on-demand SSB on the cell is non-cell-defining SSB. We cannot find any strong motivation for the agreement. However, for further progress and focusing other remaining issues, we can live with the agreement.

Proposal 2: Regarding whether on-demand SSB is cell-defining or not, additional support of CD-SSB located on sync-raster as OD-SSB is not necessary.

In Case #2 (i.e., Always-on SSB is periodically transmitted on the cell), there are several issues regarding time and frequency locations of on-demand SSB and spatial relationship between always-on SSB and on-demand SSB.

Regarding the time location of on-demand SSB, in the last meeting, an agreement was reached on the configuration method for on-demand SSB in Case #1, which is based on two parameters such as SFN offset and half frame index relative to a reference point as captured above. Similarly, in Case #2, there is no reason to adopt different configuration method from Case #1.

Proposal 3: For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell),

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

Regrading frequency location of on-demand SSB, if always-on SSB is CD-SSB on a synchronization raster, the frequency location of on-demand SSB should be different from the frequency location of always-on SSB. If both the on-demand SSB and the always-on SSB share the same frequency location, it may cause ambiguity for legacy UEs. On the other hand, if always-on SSB is CD-SSB and not on a synchronization raster, the frequency location of on-demand SSB can be either the same or different from that of always-on SSB, subject to its configuration.

Proposal 4: Regarding whether always-on SSB is CD-SSB on a synchronization raster or not, the followings should be supported.

- **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.**

Regarding multiplexing between always-on SSB and on-demand SSB for Case #2, it is also related with frequency location of on-demand SSB and two cases were identified in RAN1#118bis meeting as follows [5]:

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 case of Mux-Case #1, no time domain overlap between always-on SSB and on-demand SSB is allowed, which imposes constraints on scheduling flexibility. In case of Mux-Case #2, it ensures the scheduling flexibility. However additional procedure is required to prevent conflicts between always-on SSB and on-demand SSB when always-on SSB and on-demand SSB are overlapped in both time and frequency domains. A simple approach to resolving such conflicts is to drop one of them when the collision occurs. If the overlap occurs in time domain but not in frequency domain, both SSBs can be transmitted. However, to ensure network energy efficiency, transmitting only one of them would be preferable. In this case, it is better to drop on-demand SSB rather than always-on SSB in order to minimize the impact on legacy UEs.

Proposal 5: Regarding multiplexing between always-on SSB and on-demand SSB for Case #2, it is proposed to support

- **Mux-Case #2: Always-on SSB and on-demand SSB overlap at least in time or frequency domain**
- **When the overlap between always-on SSB and on-demand SSB occurs, only one of them is transmitted.**
    - **It will be better to drop on-demand SSB rather than always-on SSB in order to minimize the impact on legacy UEs.**

Regarding the spatial relation between always-on SSB and on-demand SSB, there is an FFS point which is whether to support the case where SSB indices within on-demand SSB burst can be subset of SSB indices within always-on SSB burst. In our opinion, there is no strong motivation to support the subset of SSB indices within always-on SSB burst. The energy-saving gain obtained by using a subset is expected to be marginal. Additionally, if this is supported, additional considerations such as SSB-RO mapping may arise due to the differences between the actually transmitted always-on SSB and on-demand SSB.

Proposal 6: Regrading the spatial relation between always-on SSB and on-demand SSB, it is proposed NOT to support the subset of SSB indices within always-on SSB burst.

2.3 Signaling of on-demand SSB operation

In RAN1#118bis meeting, it was agreed to support RRC based and MAC CE based signaling to indicate on-demand SSB transmission [5]. In case of RRC based signaling, it supports to indicate on-demand SSB transmission on the cell at least for the case where this RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration. We think a separate RRC signaling for on-demand SSB indication is less efficient than other methods such as MAC CE and DCI based signaling and also not suitable for dynamic indication. Therefore, it is not necessary to consider whether to support RRC based signaling for other cases. In case of MAC CE based signaling, separate and/or single signaling is up to RAN2 discussion. Thus, it is also unnecessary to discuss further in RAN1.

Proposal 7: In case of RRC based signaling to indicate on-demand SSB transmission, it is not necessary to consider other cases except for the agreed case where the RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration.

Proposal 8: In case of MAC CE based signaling to indicate on-demand SSB transmission, it is up to RAN2 discussion.

In case of DCI based signaling, it is still FFS. If DCI based signaling can be also used for SCell activation as well as indication of on-demand SSB transmission, it will cause a large specification impact since there is no DCI based signaling for SCell activation. Therefore, it is preferable to use DCI based signaling to indicate on-demand SSB transmission only, i.e., separate signaling. Unlike RRC based and MAC CE based signaling, DCI based signaling can be applicable to any scenarios such as Scenario #2, #2A, and #3A.

Proposal 9: In addition to RRC based and MAC CE based signaling to indicate on-demand SSB transmission, it is proposed to support DCI based signaling to indicate on-demand SSB transmission.

- **DCI based signaling is separate signaling and only applicable to indicate on-demand SSB transmission.**
- **Details can be discussed further.**

In RAN1#117 meeting, the set of information such as frequency location, SSB periodicity, and SSB positions within an SSB burst were agreed to be signaled via higher layer and known by a UE [4]. In addition to that, at least for Case #1 (i.e., no always-on SSB on the cell), more parameters such as subcarrier spacing, physical cell ID, and downlink transmit power were added in RAN1#118bis meeting [5]. The agreed set of parameters are already existed in the existing RRC parameters for SCell configuration, e.g., *ServingCellConfigCommon* or *ServingCellConfig* as shown in Table 1. Therefore, at least for Case #1 those parameters can be reused without any specification impact since there is no always-on SSB on the cell in Case #1. Only the parameters for the time location of the on-demand SSB burst that were agreed in the last meeting, such as SFN offset and half frame index, are not present in such IEs. Therefore, the parameters for time location of on-demand SSB burst should be added. With the information, a UE can detect on-demand SSB without exhaustive search. As mentioned in the above, in Case #1 there is no always-on SSB on the cell, therefore the existing parameters can be reused at least for Case #1. In Case #2, always-on SSB is periodically transmitted on the cell. Therefore, separate new parameters might be needed for on-demand SSB configuration. However, some of parameters can be shared between always-on SSB and on-demand SSB such as physical cell ID, subcarrier spacing, and so on. Therefore, it can be discussed further whether sperate new parameters for on-demand SSB configuration for Case #2 are needed.

Table 1. List of existing parameters for SSB configuration

Parameters for on-demand SSB	Existing RRC parameter	IE
SCell index	*sCellIndex*	*SCellConfig*
Frequency of the on-demand SSB	*ARFCN-valueNR*	*FrequencyInfoDL*
SSB positions within an on-demand SSB burst	*ssb-PositionsInBurst*	*ServingCellConfigCommon or ServingCellConfig*
Periodicity of the on-demand SSB	*ssb-periodicityServingCell*	*ServingCellConfigCommon or ServingCellConfig*
Sub-carrier spacing of the on-demand SSB	*ssbSubcarrierSpacing*	*ServingCellConfigCommon or ServingCellConfig*
Physical Cell ID of the on-demand SSB	*physCellId*	*ServingCellConfigCommon or ServingCellConfig*
Downlink transmit power of on-demand SSB	*ss-PBCH-BlockPower*	*ServingCellConfigCommon or ServingCellConfig*

Proposal 10: For on-demand SSB operation,

- **Most of parameters except for time location of on-demand SSB burst are already present in existing RRC IE, *ServingCellConfigCommon* or *ServingCellConfig* and can be reused for Case #1 and Case #2. In addition to the existing parameters, the following parameters should be added.**
  - **SFN offset and half frame index**
- **FFS: how to configure the parameters depending on Case #1 and Case #2**

2.4 Transmission of on-demand SSB

Regarding MAC CE based signaling for on-demand SSB burst(s) indication, as shown in the above Time instance A was agreed with two remaining working assumptions which will be discussed based on the related RAN4 response. If DCI based signaling is supported, the similar principle as MAC CE i.e., existing timeline for DCI can be applied. We do not support separate RRC based signaling for indicating on-demand SSB transmission.

In the last meeting, two options for deactivation of on-demand SSB transmission were agreed as follows:

Agreement

For a cell supporting on-demand SSB SCell operation, support at least the following options to deactivate on-demand SSB transmission from a UE perspective.

- Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication
  - Deactivation by RRC is up to RAN2
  - FFS: Which scenario Option 1 is used
- Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated
  - FFS: Whether Option 4, 4a is needed in addition to Option 2
  - FFS: Whether the value of N can be implicitly determined using a timer

The deactivation procedure is also related with the on-demand SSB transmission behaviors. In cases of Option 1, it requires additional signaling procedure and cause extra signaling. On the other hand, in case of Option 2, additional signaling procedure and extra signaling overhead are not necessary. Therefore, it is preferable to support Option 2 as the default operation and use Option 1 as a supplementary mechanism for Option 2 e.g., when the N value is not configured or to deactivate the on-demand SSB while it is being transmitted based on the N value. We do not prefer additional support for Option 4 and/or 4A on top of Option 2. In cases of Option 4 and 4A, on-demand SSB will be transmitted periodically as legacy behavior until the activated SCell is deactivated. It will cause the network energy consumption, and the energy saving gain will be marginal. Regarding whether the value of N can be implicitly determined using a timer, it is not preferable since the required number of bits for Option 2 i.e., N can be smaller than that of timer from a signaling perspective. In order to support Option 2, the value of N for on-demand SSB bursts should be included in the on-demand SSB configuration information.

Proposal 11: It is proposed to support Option 2 as the default operation and Option 1 as supplementary mechanism for Option 2.

- **Option 1 is supported when the number of N for on-demand SSB bursts is not configured.**

Proposal 12: It is not necessary to support Option 4, 4A in addition to Option 2.

Proposal 13: For Option 2, it is not necessary to use timer instead of the number of N.

Proposal 14: For Option 2, it is proposed to include the value of N for on-demand SSB bursts in the on-demand SSB configuration information.

2.5 Measurement based on on-demand SSB

Regarding measurement based on on-demand SSB for Case #2, two options were discussed in RAN1#118bis meeting as follows:

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

It depends on how to support multiplexing between on-demand SSB and always-on SSB. If no overlap between always-on SSB and on-demand SSB is allowed, separate CSI report configuration can be supported. However, if the overlap between them is allowed and only one of them can be transmitted whenever the overlap occurs, then one CSI report configuration which is associated with both of on-demand SSB and always-on SSB can be considered.

Proposal 15: Regarding measurement based on on-demand SSB, it is proposed to postpone the discussion until multiplexing between always-on SSB and on-demand SSB for Case #2 is determined.

3 Summary

In this contribution, we made the following proposals on on-demand SSB SCell operation.

Proposal 1: In addition to previous agreed scenarios, it is proposed to consider #3A for further discussion for on-demand SSB SCell operation and preclude Scenario #3B.

Proposal 2: Regarding whether on-demand SSB is cell-defining or not, additional support of CD-SSB located on sync-raster as OD-SSB is not necessary.

Proposal 3: For Case #2 (i.e., Always-on SSB is periodically transmitted on the cell),

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

Proposal 4: Regarding whether always-on SSB is CD-SSB on a synchronization raster or not, the followings should be supported.

- **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: Regarding multiplexing between always-on SSB and on-demand SSB for Case #2, it is proposed to support

- **Mux-Case #2: Always-on SSB and on-demand SSB overlap at least in time or frequency domain**

- **When the overlap between always-on SSB and on-demand SSB occurs, only one of them is transmitted.**
    - **It will be better to drop on-demand SSB rather than always-on SSB in order to minimize the impact on legacy UEs.**

Proposal 6: Regrading the spatial relation between always-on SSB and on-demand SSB, it is proposed NOT to support the subset of SSB indices within always-on SSB burst.

Proposal 7: In case of RRC based signaling to indicate on-demand SSB transmission, it is not necessary to consider other cases except for the agreed case where the RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration.

Proposal 8: In case of MAC CE based signaling to indicate on-demand SSB transmission, it is up to RAN2 discussion.

Proposal 9: In addition to RRC based and MAC CE based signaling to indicate on-demand SSB transmission, it is proposed to support DCI based signaling to indicate on-demand SSB transmission.

- **DCI based signaling is separate signaling and only applicable to indicate on-demand SSB transmission.**
- **Details can be discussed further.**

Proposal 10: For on-demand SSB operation,

- **Most of parameters except for time location of on-demand SSB burst are already present in existing RRC IE, *ServingCellConfigCommon* or *ServingCellConfig* and can be reused for Case #1 and Case #2. In addition to the existing parameters, the following parameters should be added.**
    - **SFN offset and half frame index**
- **FFS: how to configure the parameters depending on Case #1 and Case #2**

Proposal 11: It is proposed to support Option 2 as the default operation and Option 1 as supplementary mechanism for Option 2.

- **Option 1 is supported when the number of N for on-demand SSB bursts is not configured.**

Proposal 12: It is not necessary to support Option 4, 4A in addition to Option 2.

Proposal 13: For Option 2, it is not necessary to use timer instead of the number of N.

Proposal 14: For Option 2, it is proposed to include the value of N for on-demand SSB bursts in the on-demand SSB configuration information.

Proposal 15: Regarding measurement based on on-demand SSB, it is proposed to postpone the discussion until multiplexing between always-on SSB and on-demand SSB for Case #2 is determined.

4 References

[1] Chair's notes, RAN1#119, November 2024.
[2] RP-242354, "Revised WID: Enhancements of network energy savings for NR," Ericsson.
[3] Chair's notes, RAN1#116bis, April 2024.
[4] Chair's notes, RAN1#117, May 2024.
[5] Chair's notes, RAN1#118bis, October 2024.