**3GPP TSG RAN WG1 Meeting #110 R1-22xxxxx**

**Toulouse, France, August 22nd – 26th, 2022**

**Source: Moderator (Qualcomm)**

**Title:** **Draft summary on BWP operation without bandwidth restriction**

**Agenda Item:** **5**

**Document for:** **Discussion and Decision**

# **Background**

RAN1 has received a LS from RAN2 regarding BWP operation without bandwidth restriction [1], which contains following questions.

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| **Question 1:**Whether it is a valid scenario in the standard to support the operation of BWP without SSB where the UE does not perform BM/RLM/BFD due to the lack of necessary reference signal (SSB and CSI-RS) in the active BWP.**Question 2:**If the answer to question 1 is that this is not valid, how should the UE perform BM/RLM/BFD when the active BWP does not contain SSB. |

At the RAN1#109-e meeting, this has been discussed extensively while no conclusion has been made [2].

At the RAN#96 meeting, a guidance from RAN plenary to the WGs has been agreed [3]:

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| To task the relevant Working Groups (RAN1, 2, 4) to make progress on their discussions related to the RAN2 LS in R2-2204009, aim to ensure that Feature Group 6-1a “*bwp-WithoutRestriction*” works in an early implementable form in R18, or, possible R17, and report progress to RAN#97. |

This document summarizes the discussion and outcome for this issue.

# **Companies’ views from [4] – [12]**

Views from companies are summarized in the following Table.

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| Company(ies) | View |
| Qualcomm Incorporated, Vodafone [4] | Proposal:* New UE capability signalling is specified in Rel-17 with the following details:
	+ The UE capability is optional and per-band that prerequisites FG6-1a
	+ The UE capability indicates that the UE can perform SSB-based RLM, SSB-based BM (if supported), SSB-based BFD (if supported), and SSB-based CBD (if supported), where the SSB maybe outside active DL BWP but is in the bandwidth of the carrier configured by *carrierBandwidth* of *SCS-SpecificCarrier* in *ServingCellConfig*, *DownlinkConfigCommon*, and *DownlinkConfigCommonSIB*
	+ PDCCH/PDSCH and CSI-RS are still received within the active DL BWP
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| ZTE [5] | Proposal 1: Introduce new UE capability(ies) for BWP operation without restriction with SSB that is within or outside the active DL BWP for RLM/BM/BFD without gap.* New UE capability(ies) is applied to RLM for P(S)Cell and applied to BM/BFD for both P(S)Cell and SCell.
	+ FFS: capability(ies) details and RAN1 spec impact (if any) until RAN1#110
	+ FFS: from which release to introduce this new UE capability(ies).
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| Nokia, Nokia Shanghai Bell [6] | Proposal 1: UE supporting *bwp-WithoutRestriction* supports all SSB-based procedures also when the SSB is outside the active DL BWP. Proposal 2: Make the following clarification to the TS38.213Proposal 3: Suggest to RAN2 to make the following corrections to the TS 38.300Proposal 4: Suggest to RAN2 to make the following clarification to the TS 38.306 |
| vivo [7] | Proposal 1: RAN1 to provide the following answer to Question 1 of RAN2 LS [1]* From the current specification, it is NOT a valid scenario in the standard to support the operation of BWP without SSB where the UE does not perform RLM due to the lack of necessary reference signal (SSB and CSI-RS) in the active BWP.
* From the current specification it is a valid scenario in the standard to support the operation of BWP without SSB where the UE does not perform BM or BFD due to lack of necessary reference signal

Proposal 2: Adopt the following proposal and reply the Question 2 of RAN2 LS and inform RAN4 accordingly* Introduce new UE capability for BWP operation without restriction with SSB that is outside the active DL BWP for RLM/BM/BFD without gap
	+ TBD the new UE capability is introduced from Rel-16 or Rel-17
	+ RAN1 to work on the detailed specification changes accordingly
	+ The capability(ies) does not change the following:
		- CSI-RS measurement/reception procedures (i.e., CSI-RS is measured/received within the active DL BWP)
		- RRM measurement procedures
	+ The followings can be further discussed in later releases, e.g. Rel-18
		- Potential additional new UE capability for BWP operation without restriction with SSB that is outside the active DL BWP for RLM/BM/BFD with gap
		- Support of NCD-SSB for all UE types
	+ Inform the decision to RAN2/RAN4
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| MediaTek Inc. [8] | Proposal 1: Reply RAN2’s Question 1 with the response “No, it is not a valid scenario.”Proposal 2: Reply RAN2’s Question 2 with “UE should perform RLM/BM/BFD based on CSI-RS when its active DL BWP does not contain SSB.”Proposal 3: In the reply LS to RAN2, inform RAN2 that from RAN1’s perspective it should be regarded as an error case when UE indicates the support for FG 6-1a but not the support for FGs 1-7/2-24/2-31.Proposal 4: For non-RedCap UEs, at least a small gap should be allocated for the UE to perform SSB-based RLM/BFD/CBD/BM using SSBs outside active BWP.Proposal 5: The support for SSB-based L1 measurements using SSBs outside active BWP is applicable to PCell/PSCell only.Proposal 6: R17 NCSG design including requirements, UE reporting values, and UE capability reporting framework can be considered as a starting point if a new UE capability is agreed to support UE performing L1 measurements using SSBs outside active BWP.Proposal 7: Enabling FG 6-1a with CSI-RS based L1 measurements should target for Rel-17 while enabling FG 6-1a with SSB based L1 measurements should target for Rel-18. |
| NEC [10] | Proposal:* For sPCell, network should not configure (or activate) a BWP without CD-SSB for a UE capable of FG6-1a but not capable of FG1-7
* For SCell(s), network may configure and activate a BWP without SSB for a UE capable of FG6-1a but not capable of FG1-7
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| Huawei, HiSilicon [11] | Proposal: Gap-based measurement based on SSB outside active BWP is required for a UE supporting FG6-1a. RAN1 to conclude whether to define associated UE capability and send LS to RAN4 for finalization of requirement aspects. |
| Intel Corporation [12] | Proposal 1:* For the scenario wherein a UE supports FG 6-1a and does not support CSI-RS based RLM/BM/BFD as raised by RAN2 LS in R1-2203043(R2-2204009), both of the following new UE capabilities can be considered for Rel-17/18 (FFS):
	+ New\_Cap\_X: UE supports BWP operation without bandwidth restriction (as in FG 6-1a) including measurements using SSB that may be within or outside the active DL BWP for RLM/BM/BFD without gap
	+ New\_Cap\_Y: UE supports BWP operation without bandwidth restriction (as in FG 6-1a) but expects configuration of NCD-SSB in an active DL BWP that does not include a CD-SSB. The UE performs RLM/BM/BFD using NCD-SSB in this active DL BWP.
	+ UE may indicate only one of the two new capabilities.

Proposal 2:* To address the scenarios wherein a UE supports FG 6-1a and does not support CSI-RS based RLM/BM/BFD,
	+ If UE indicates support of New\_Cap\_X, RLM/BM/BFD are enabled by using SSB-based measurements wherein the SSB can be outside the active DL BWP;
	+ Else, if UE indicates support of New\_Cap\_Y, RLM/BM/BFD are enabled by using NCD-SSB-based measurements wherein the NCD-SSB is configured within the active DL BWP;
	+ Else, active DL BWP may only be configured to include CD-SSB (effectively falls back to FG #6-1).
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# **1st round**

## **3.1 General**

From the contributions, following seems an agreeable common understanding:

**FL Proposal 1:**

* **Agree following statements:**
	+ **It is NOT a valid scenario in the standard to support the operation of BWP without SSB where the UE does not perform RLM/BM/BFR due to the lack of necessary reference signal (SSB and CSI-RS) in the active BWP.**
	+ **Solution/clarification is necessary if a UE indicates support of FG6-1a without support of CSI-RS based RLM/BM/BFR**

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| Company | View |
| Nokia, NSB | On the 1st bullet, we tend to think that this is a sensible assumption for practical system operation for PCell, even though it is not something that the specification appears to mandate. So even though we agree with the intent, we would slightly favour a bit less strong wording, e.g. along the lines: “RAN1 doesn’t consider it a practical scenario to configure the operation of BWP without SSB…”On the 2nd bullet, this seems to be evident based on RAN1#109 discussions and contributions submitted to this meeting |
| Vodafone | We agree with the statements |
| Apple | In general, we think we need to discuss the response to the next RANP meeting to help RANP discussion on resolving the concern on FG6-1a.However, we do not know if the first bullet is that helpful, since it can be simply implying that if a UE does not support CSI-RS based RLM/BM/BFR, NW cannot configure the UE the operation of BWP without SSB in active BWP.In our view, the fundamentally question we need to answer in RAN1 is whether RAN1 thinks it is okay to support UE RLM/BM/BFR measurement on SSB outside active BWP, which is prohibited in the current RAN1 specification. |
| Intel | Agree in principle and, on the wording, we would like to second the suggestion from Nokia. |
| CMCC | For the first question, we also think this scenarios is not valid. Since in TS38.300, take RLM as an example, there is description that ”SSB-based RLM is based on the SSB associated to the initial DL BWP and can only be configured for the initial DL BWP and for DL BWPs containing the SSB associated to the initial DL BWP. For other DL BWPs, RLM can only be performed based on CSI-RS.”. So it a UE report FG6-1a and is configured a active BWP without SSB, then gNB will configure CSI-RS for such measurement.For the second bullet, we think the intention is to answer Q2 of RAN LS “If the answer to question 1 is that this is not valid, how should the UE perform BM/RLM/BFD when the active BWP does not contain SSB.” . So the question is about **how to do the measurement for BWP without SSB**, and it does not restrict the scenario to UE without support of CSI-RS based RLM/BM/BFR. |

As for the solution/clarification, there are three general directions in the contributions:

* Direction 1: Support SSB-based RLM/BM/BFR when SSB is not within active DL BWP
* Direction 2: Make sure that SSB is within active DL BWP
* Direction 3: Require to support CSI-RS-based RLM/BM/BFR to enable active DL BWP not containing SSB

However, FL suggests RAN1 to move forward with Direction 1 due to the following reasons:

* Direction 2 does not ensure that FG6-1a “*bwp-WithoutRestriction*” works and lose the whole benefit of FG6-1a. Considering the RAN-P guideline, this should not be a solution.
* It is clear that CSI-RS based RLM/BM/BFR is a solution to enable FG6-1a if the UE supports and network deploys CSI-RS based RLM/BM/BFR. However, the concerned scenario in the RAN2’s LS is the case where a UE supports FG6-1a but not CSI-RS based RLM/BM/BFR.
* In addition, RAN plenary tasked WGs to make progress on their discussions related to the RAN2 LS in R2-2204009, aim to ensure that Feature Group 6-1a “*bwp-WithoutRestriction*” works – meaning that the RAN plenary’s concerned scenario is also the case where the UE supports FG6-1a but not CSI-RS based RLM/BM/BFR.

For Direction 1, there has been a concern on enabling SSB-based RLM/BM/BFR when SSB is not within active DL BWP without any new capability with respect to potential NBC issue. Therefore, FL suggest to agree to introduce new UE capability signalling that indicates support of overall SSB-based RLM/BM/BFR even when SSB is not within active DL BWP. Details of the new UE capability should be the next step.

**FL Proposal 2:**

* **Introduce new UE capability signalling that indicates support of SSB-based RLM/BM/BFR even when SSB is not within active DL BWP**

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| Company | View |
| Nokia, NSB | We agree with the general direction outlined by the feature lead. However, whether this calls for a new UE capability, or if the existing FG6-1a could be used for this purpose could be left for RAN2 and RAN to discuss and decide. Our understanding that no UE can indicate FG6-1a based on existing specifications because it is not clear what that capability implies. Due to this the FG6-1a can only be indicated after the UE has implemented the necessary clarifications originating from the currently ongoing discussions. Hence it would be a valid option to use the existing FG6-1a signalling after the clarifications just as well as introducing a new UE capability. |
| Vodafone | We support the introduction of a new capability to clarify UE’s behaviour by performing SSB based measurements. We would also be OK of reutilizing the existing capability granted that no NBC issues are generated from it |
| Apple | If capability is introduced, we prefer to introduce the capability in RAN4 subject to the potential RAN4 work. RLM/BFR/BM measurement on SSB outside active BWP is very similar to inter-frequency L3 (RRM) measurement. It is typically a RAN4 topics including * Whether gap based, or gap-less measurement is assumed. In RAN4, there is also discussion of ncsg (Network Controlled Short Gap)
* Whether scheduling restriction is needed
* Whether interruption is needed

We think some RANP discussion is needed in order to determine how to finish this work among different WGs. |
| Intel | Agree. For the idea of reusing FG 6-1a as suggested by Nokia, we think a separate capability, that could have FG 6-1a as a prerequisite, would be a cleaner option. For instance, currently a UE can indicate support of FG 6-1a along with support of CSI-RS based RLM/BM/BFR, implying NBC change unless further conditioning is defined.  |
| CMCC | Firstly, we think the traditional behavior is to do measurements related to RLM, BM, and BFR either by SSB or by CSI-RS, that's the traditional framework, so if a UE doesn't support CSI-RS, it seems meaningless to support FG 6-1a, according to description in TS38.300. And the sentence in TS38.213 also convinces this, such as “UE is not required to monitor downlink radio link quality in DL BWPs other than the active BWP.” so for such BWP, it can only relys on CSI-RS within this BWP. Secondly, if the capability in FL proposal2 is further introduced, it does not completely solve the problem, since some UEs may not support this optional capability. gNB still has to configure CSI-RS for UE that does not support the optional capability. And finally, CSI-RS based measurement is mandatory with capability signalling, so it is high priority than the optional capability. So take CSI-RS based capability as the baseline solutions for Q2 seems more reasonable. |

## **3.2 Details**

The next step would be to clarify details of the new UE capability signalling. FL considers that following aspects are common understanding among companies in RAN1.

* RedCap UE is not the scope of this discussion. For RedCap, there is a separate discussion with a separate FG. The discussion here is limited to non-RedCap UEs supporting FG6-1a.
* Regarding the timeline, RAN plenary guidance is “WGs must ensure that FG6-1a works in an early implementable form in R18, or possible R17”. If the new capability signalling is in R18 ASN.1, it is no longer early implementable. Therefore, the signalling has to be available in R17 ASN.1.
* It must be clear that the new UE capability signalling is not “stand-alone” capability signalling indicating support of SSB-based RLM/BM/BFR itself; it indicates support of the following.
	+ RLM using SSB outside active DL BWP,
	+ BM using SSB outside active DL BWP if the UE supports SSB-based BM (via *maxNumberSSB-CSI-RS-ResourceOneTx*), and
	+ BFR using SSB outside active DL BWP if the UE supports SSB-based BFR (via*maxNumberSSB-BFD* and *maxNumberCSI-RS-SSB-CBD*)
* The SSB outside active DL BWP used for RLM/BM/BFR is still within the configured channel bandwidth of the carrier.
* The CSI-RS measurement/reception procedures (i.e., CSI-RS is measured/received within the active DL BWP) and RRM measurement procedures are not relevant to the new UE capability.

**FL Proposal 3:**

* **The new UE capability signalling is for UEs supporting FG6-1a and is not applicable to RedCap UE**
* **The new UE capability signalling is to be specified in Rel-17 ASN.1**
* **The new UE capability signalling indicates support of:**
	+ **RLM using SSB outside active DL BWP,**
	+ **BM using SSB outside active DL BWP if the UE supports SSB-based BM (via maxNumberSSB-CSI-RS-ResourceOneTx), and**
	+ **BFR using SSB outside active DL BWP if the UE supports SSB-based BFR (via maxNumberSSB-BFD and maxNumberCSI-RS-SSB-CBD)**
* **SSB used for RLM/BM/BFR shall be within the configured channel bandwidth of the carrier**
* **The new UE capability signalling is irrelevant to CSI-RS measurement/reception procedure and RRM measurement procedures**

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| Company | View |
| Nokia, NSB | As indicated in our response to proposal 2, whether this is a new capability or clarified FG6-1a should be left to RAN/RAN2. In this light* 1st bullet: OK with the intention, but reference to “new” would not necessarily apply
* 2nd bullet: would update this to “Up to RAN2 and RAN to discuss if a new capability (e.g- to Rel-17) is introduced, or if clarified *bwp-WithoutRestriction* is used for this purpose
* 3rd bullet: OK with the intention, but reference to “new” would not necessarily apply. OK with the sub-bullets
* 4th bullet: OK
* 5th bullet: OK with the intention, but reference to “new” would not necessarily apply. OK with the sub-bullets
 |
| Vodafone | We are supportive of FL’s proposed direction and we also agree that it is important to emphasize the RAN’s decision on having an early implementable form already in R17 |
| Apple | See comment to FL proposal 2 |
| Intel | Support. As responded to FL proposal 2, new UE capability is preferred to avoid potential NBC issue.  |
| CMCC | The details can be determined when proposal 2 make progress. |

There are diverged views on whether a gap is necessary for a UE to measure SSB outside active DL BWP. For RRM measurement, “*NeedForGapsIntraFreq*” and “*NeedForNCSGIntraFreq*” have been specified in Rel-16 and Rel-17, respectively, to accommodate similar variations of UEs. According to TS38.331:

* With “*NeedForGapsIntraFreq*”, a UE indicates whether measurement gap is required for the UE to perform intra-frequency SSB based measurements on the concerned serving cell via *gapIndicationIntra* = {*gap*, *no-gap*}.
	+ Value *gap* indicates that a measurement gap is needed if any of the UE configured BWPs do not contain the frequency domain resources of the SSB associated to the initial DL BWP.
	+ Value *no-gap* indicates a measurement gap is not needed to measure the SSB associated to the initial DL BWP for all configured BWPs, no matter the SSB is within the configured BWP or not.
* With “*NeedForNCSGIntraFreq*”, a UE indicates whether measurement gap or NCSG is required for the UE to perform intra-frequency SSB based measurements on the concerned serving cell via *gapIndicationIntra* = {*gap*, *ncsg*, *nogap-noncsg*}.
	+ Value *gap* indicates that a measurement gap is needed if any of the UE configured BWPs do not contain the frequency domain resources of the SSB associated to the initial DL BWP.
	+ Value *ncsg* indicates that a NCSG is needed if any of the UE configured BWPs do not contain the frequency domain resources of the SSB associated to the initial DL BWP.
	+ Value *nogap-noncsg* indicates that neither a measurement gap nor a NCSG is needed to measure the SSB associated to the initial DL BWP for all configured BWPs, no matter the SSB is within the configured BWP or not.

From the above, it would be fair to say that for the purpose of SSB-based RLM/BM/BFR, both types of UEs (no-gap, (small) gap) should be considered. However, we have to take into account the RAN plenary agreement: the solution shall be early implementable in R18 or possible R17. Introduction of (small) gap for SSB measurement for RLM/BM/BFR may require RAN4 discussion on potential new RAN4 performance requirements which would take time to complete. On the other hand, the feature “without gap” does not need new RAN4 requirements – the UE that indicates support “without gap” just has to meet all the existing RAN4 requirements. Because of this, it is clear that the case without gap can be implementable earlier than R18 while the case with gap may need RAN4 discussion.

FL suggest to consider both “without gap” and “with (small) gap”, where the case without gap is specified in Rel-17 while the case with (small) gap is up to RAN4.

**FL Proposal 4:**

* **The new R17 UE capability signalling indicates support of RLM/BM/BFR using SSB outside active DL BWP without gap**
	+ **No new RAN4 performance requirements for RLM/BM/BFR are expected to be introduced from RAN1 point of view**
* **Separately, RAN1 expects RAN4 to discuss RLM/BM/BFR using SSB outside active DL BWP with gap**

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| Company | View |
| Nokia, NSB | OK with the intention, but reference to “new” would not necessarily apply as per our response to proposal 2. |
| Vodafone | Agree with the proposed direction |
| Apple | We do not think RAN1 can determine that there is new RAN4 performance requirement.  |
| Intel | OK. |
| CMCC | Whether no gap can be support may also need confirmation from RAN4.  |

[8] proposes an additional restriction – that is RLM/BM/BFR using SSB outside active DL BWP is limited to P(S)Cell only. However, the existing FG6-1a (*bwp-WithoutRestriction*), *NeedForGapsIntraFreq*, and *NeedForNCSGIntraFreq* are all per-band capabilities and do not have such restriction/limitation. FL does not see a particular benefit of limiting the feature for P(S)Cell only. With that, following is proposed.

**FL Proposal 5:**

* **The new UE capability signalling is reported per-band**

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| Company | View |
| Nokia, NSB | The capability signalling should be per band. Could discuss further if the application of the BWP outside of the active BWP configuration should be restricted to the PSCell, but that should not have any ASN.1 impact. |
| Vodafone | We support the proposal |
| Apple | Again, we believe RAN4 is the right WG to carry about the work. But in general, we are fine to support some UE that is capable of performing RLM/BFR/BM measurement based on SSB outside active BWP. |
| Intel | OK. |

# **2nd round**

## **4.1 Draft LS reply to RAN2**

RAN1 thanks RAN2 regarding the questions on BWP operation without bandwidth restriction for pre-Release-17 and non-RedCap. RAN1’s answers are provided below:

**Question 1:**

Whether it is a valid scenario in the standard to support the operation of BWP without SSB where the UE does not perform BM/RLM/BFD due to the lack of necessary reference signal (SSB and CSI-RS) in the active BWP.

**[RAN1]: To be discussed in the 2nd step**

**Question 2:**

If the answer to question 1 is that this is not valid, how should the UE perform BM/RLM/BFD when the active BWP does not contain SSB.

**[RAN1]: To be discussed in the 2nd step**

# **Conclusion**

TBA

# **Reference**

1. R1-2203043, LS on BWP operation without bandwidth restriction, RAN2
2. R1-2205455, Summary of [109-e-AI5-LSs-01]: Email discussion for incoming LS on BWP operation without bandwidth restriction, Moderator (Qualcomm Incorporated)
3. 3GPP RAN#96, Chairman’s note.
4. R1-2207165 Discussion on RAN2 LS on BWP operation without bandwidth restriction Qualcomm Incorporated, Vodafone
5. R1-2205969 [Draft] Reply LS on BWP operation without bandwidth restriction ZTE
6. R1-2206427 On FG 6-1a BWP without restriction Nokia, Nokia Shanghai Bell
7. R1-2206705 Discussion on BWP without restriction vivo
8. R1-2206998 Discussion on RAN2 LS on BWP operation without bandwidth restriction MediaTek Inc.
9. R1-2206999 Draft Reply LS on BWP operation without bandwidth restriction MediaTek Inc.
10. R1-2207430 Discussion on LS on BWP operation without bandwidth restriction NEC
11. R1-2207515 On supporting FG 6-1a for non-RedCap UEs Huawei, HiSilicon
12. R1-2206530 On FG 6-1a and NCD-SSB for Non-RedCap UEs Intel Corporation