**3GPP TSG RAN WG1 Meeting #109-e R1-22xxxxx**

**E-meeting, May 9th – 20th, 2022**

**Source: Moderator (Qualcomm Incorporated)**

**Title:** **Summary of [109-e-AI5-LSs-01]: Email discussion for incoming LS on BWP operation without bandwidth restriction**

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

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

# **Introduction**

This document is the summary of email discussion for the following:

[109-e-AI5-LSs-01] Email discussion for incoming LS on BWP operation without bandwidth restriction ([R1-2203043](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2203043.zip)) by May 13 – Fred (Qualcomm)

# **Background**

NR supports BWP operation without bandwidth restriction (FG6-1a) as an optional feature with per-band UE capability signalling. If a UE indicates support of this feature, the UE can be configured with a DL BWP that does not include the bandwidth of CORESET#0 (if configured) and SSB for PCell/PSCell, and a DL BWP that does not include SSB for SCell. This feature prerequisites support of basic BWP operation (FG6-1) or adaptation of BWP (FG6-2, 6-3, or 6-4).

NR supports RLM using CSI-RS (FG1-7). This is a mandatory feature with per-band UE capability signalling – therefore, there are cases where the UE does not indicate support of CSI-RS based RLM (e.g., IODT not achieved). RLM using SSB and CSI-RS (FG1-8) is an optional feature that prerequisites FG1-7.

NR supports BM using SSB and/or CSI-RS (FG2-24). There is a per-band UE capability signalling for this feature, but mandatory or not depends on components and FRs. According to components 1 and 2 of FG2-24, SSB based BM of >=8 is mandatory for FR2 but that of >=8 is mandatory with capability signalling for FR1, while CSI-RS based BM is mandatory with capability signalling – therefore, there are some cases where the UE does not indicate support of SSB based BM and/or CSI-RS based BM (e.g., IODT not achieved).

NR supports BFD using SSB and/or CSI-RS (FG2-31). Separate per-band UE capability signalling for components 1, 2, and 3 are defined. CSI-RS based BFD (component 1) and SSB-based BFD (component 2) are mandatory features with per-band UE capability signalling for FR2, and optional features with per-band UE capability signalling for FR1. Therefore, there are some cases where the UE does not indicate support of SSB based BFD and/or CSI-RS based BFD.

The descriptions of the corresponding UE capability signalling are copied in the Annex of this paper for reference.

As seen in the descriptions, there is no prerequisite relation between FG6-1a and {FG1-7, 2-24, 2-31}. Therefore, a UE can indicate support of FG6-1a without indicating support of FG1-7, 2-24, and/or 2-31. In this case, there could be no RS (SSB or CSI-RS) within the active DL BWP for RLM, BM, or BFD. Therefore, RAN2 came up with the following questions.

|  |
| --- |
| **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. |

# **Companies’ views**

Some companies expressed views in the contributions. Summary is provided below.

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| Contributions | Views |
| [2] | If the active DL BWP does not contain the necessary reference signal (SSB or CSI-RS), UE is not able to perform RLM on the active DL BWP. The same applies to BM/BFD. |
| [3] | It is possible that SSB is not contained by active DL BWP. However, RLM is possible to operate by using CSI-RS since FG 1-7 (CSI-RS based RLM) is mandatory UE capability. Regarding BFD, it is possible to operate at least in FR2 since FG 2-31 (Beam failure recovery) is mandatory UE capability in FR2 but optional in FR1. Regarding BM, it is possible to operate by using CSI-RS since FG 2-24 (SSB/CSI-RS for beam measurement) is mandatory UE capability. |
| [4] | * If a UE support CSI-RS based RLM/BFD/beam management, and FG6-1a, then gNB can configure it with BWPs w/o SSB, and configure CSI-RS for RLM/BFD/beam management either by implicit way or explicit way for UE on this BWP. * If a UE support FG6-1 but not FG6-1a, then gNB configures such UE with BWPs containing SSB, and RLM/BFD/beam management are based on SSB, or CSI-RS if UE report corresponding capabilities. * If a UE doesn’t not support CSI-RS based RLM/BFD/beam management, gNB configures such UE with BWPs containing SSB, and RLM/BFD/beam management are based on SSB. |
| [5] | * RAN1 answer to Q1: No. UE needs to perform BM/RLM/BFD for BWP without SSB. Otherwise, it would be difficult for the network to schedule/manage this UE. * RAN1 answer to Q2: The UE can perform BM/RLM/BFD based on the SSB out of the active BWP. |
| [6] | * It is a valid scenario in the standard to support the operation of BWP without SSB where the UE does not perform BM/BFD due to the lack of necessary reference signal (SSB and CSI-RS) in the active BWP. * 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 on PCell and PSCell (if configured).   + If the UE supports BWP operation without bandwidth restriction and does not support CSI-RS based RLM, the UE should be configured only with BWP(s) containing SSB on PCell and PSCell (if configured). |
| [7] | Reply to RAN2 that for the scenario in question 1 there is no requirement defined for UE performing BM/RLM/BFD. For a UE supporting FG6-1a, performing BM/RLM/BFD is also possible by existing UE implementations without backward compatibility issue. |
| [8] | * RAN1 answer to Q1: No, RAN1 does not think it is a valid scenario where a UE does not perform BM/RLM/BFD due to lack of reference signal for BM/RLM/BFD within the active BWP. * RAN1 answer to Q2: RAN1 agrees RAN2 that the CSI-RS based RLM/BFD (FG1-7, FG1-8, FG2-31) are not prerequisite for BWP operation without bandwidth restriction (FG6-1a). With the RAN1’s answer to Question 1, RAN1 considers that if a UE indicates support of BWP operation without bandwidth restriction (FG6-1a) but does not indicate support of CSI-RS based RLM/BFD (FG1-7, FG1-8, FG2-31), the UE shall be able to perform SSB based RLM/BFD even if the active DL BWP does not contain the SSB. |
| [9] | According to RAN1 specifications, 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 in the active BWP. |

# **1st round discussion**

**1.RLM**

Q1-1: Do you agree that a UE may indicate support of FG6-1a (BWP without restriction) for a band without indicating support of FG1-7 (CSI-RS based RLM) for the FR? If no, please explain the interaction between FG6-1a and FG1-7.

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| Company | Yes/No | Comment |
| Qualcomm | Yes | There is no prerequisite relation between FG6-1a and FG1-7. Therefore, a UE is allowed to indicate support of FG6-1a without support of FG1-7.  Updating the descriptions such that FG1-7 is a prerequisite for FG6-1a causes new restriction of operation and is a non-backward compatible change. |
| Ericsson | Yes |  |
| vivo | Unclear | Although we agree there is no dependency between FG6-1a and FG1-7 from the specification perspective, it is also clear from RAN1 specification that “UE is not required to perform radio link monitoring in DL BWPs other than the active DL BWP”, therefore it is unclear how a UE not capable of FG1-7 can perform RLM if its active DL BWP does not contain SSB. |
| Nokia, NSB | Yes | The features are not linked. Notably RLM is never done in all cells in CA configs. |
| Apple | Yes | UE does not have to support FG1-7, in case UE support FG6-1a |
| ZTE | Yes | Similar view as Qualcomm. |
| NTT DOCOMO | Yes |  |
| CATT | Yes | FG 6-1a is independent with FG 1-7 |
| Samsung | Yes | There is no dependency between FG 6-1a and FG 1-7. |
| Vodafone | Yes | However we share a similar view as Vivo |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |

Q1-2: If your answer to Q1-1 is yes, do you agree that for such UE, DL BWP that does not contain SSB can be configured and activated? Please explain why you think yes/no.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | Yes | It is specified in the description of FG6-1a that the active DL BWP may not contain SSB. If SSB shall be within the active DL BWP for such UE, the FG6-1a is useless. |
| Ericsson | Yes |  |
| vivo | Yes but | DL BWP without SSB should be supported by the UE indicating support of FG6-1a, however, as commented above, it is unclear how UE perform RLM in such case. |
| Nokia, NSB | Yes | RLM is not done in all cells, so not having RLM RS is not a must. |
| Apple | Yes | 6-1a applies to both SpCell and SCell. |
| ZTE | Yes |  |
| NTT DOCOMO | Yes/No | As other companies pointed, it should be possible for SCell. But for PCell/PSCell, UE shall be able to perform RLM as specified in TS38.133. If BWP without SSB can be configured/activated for such UE, some method to perform RLM (e.g., using SSB outside active DL BWP) would be necessary. Otherwise, DL BWP that does not contain SSB should not be configured and activated for the UE indicating support of FG6-1a without support of FG1-7. |
| CATT | Yes | Otherwise it is not a FG 6-1a, but a FG 6-1 instead. |
| Samsung | Yes | If a UE supports FG 6-1a, the UE can be configured with the DL BWP without SSB. |
| Vodafone | Yes |  |
| Huawei, HiSilicon | Yes |  |
| CMCC | It depends | If such BWP can be configured, the behavior needs to be clarified, for example, by retuning to SSB? If retuning to SSB for RLM measurement is not supported, then such BWP cannot be configured. |

Q1-3: Do you agree that it is a valid scenario where a UE does not perform RLM due to the lack of RS (SSB or CSI-RS) for RLM in the active DL BWP? If yes, please explain in which condition(s) and for which UE such no-RLM is valid. If no, please explain how RLM is enabled for such case.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | No | It is not a valid scenario. RLM is an essential function for connectivity and hence RLM should be available even for such case.  When SSB is not within the active DL BWP but the UE does not support CSI-RS based RLM, use of SSB that is not within the active DL BWP is the only way to perform RLM. The UE indicating support of FG6-1a without support of FG1-7 shall be able to use SSB that is not within the active DL BWP for RLM. |
| Ericsson | Yes | The formulation is somewhat strange. What does “valid scenario” mean? It is what the specification supports. |
| vivo |  | We think the question is a bit unclear. If the intention is to ask whether UE can work without RLM, our understanding is that RLM is an essential feature therefore it should not be possible for a UE to not perform any RLM. |
| Nokia, NSB | Yes | From RAN1 spec perspective it is not a requirement for the UE to be configured to perform RLM in a cell. SCell RLM was not even supported in Rel-15. |
| Apple | Yes | 6-1a also applies to SCell, so there is no RLM concern.  For PCell, it is up to gNB configuration. 6-1a does not force gNB to activate BWP without SSB.  gNB needs to provide RS within the active BWP for UE to perform RLM subject to UE capability. If gNB cannot configure, instead of asking UE to measure RS outside active BWP, the correct requirement is that UE does not support RLM. |
| ZTE |  | From our perspective, RLM is an essential feature at least for PCell. |
| NTT DOCOMO | No | As in our comment for Q1-2, RLM is required to perform for PCell/PSCell, and there are two possible approaches for such UE as below.  Alt.1: new UE behaviour is introduced so that the UE indicating support of FG6-1a without support of FG1-7 can monitor SSB that is not within the active DL BWP for RLM.  Alt.2: DL BWP that does not contain SSB should not be configured and activated for the UE indicating support of FG6-1a without support of FG1-7. |
| CATT | Yes&No | For PCell, RLM is essential. If the network does not configure RS for RLM in the active BWP for UE supporting FG 6-1a, the UE may perform RLM by the SSB outside its active BWP.  For Scell, the UE may not perform RLM. |
| Samsung | Yes&No | We think the current spec does not preclude the case when BWP without SSB is configured based on reported FG 6-1a, and no RS for RLM without FG 1-7. But we also have similar view with several companies that RLM is an essential operation for UE at least in PCell, and also FG 1-7 is anyway mandatory feature (with capability signalling thou). |
| Vodafone | Unclear | Similar view as Qualcomm. We would prefer to have a clear specification (not up to implementation) on how to perform RLM in the case there is lack of RS in the active DL BWP |
| Huawei, HiSilicon | Yes | The scenario is valid as allowed by specification/standard.  The LS is also asking whether it is valid scenario in the standard where the later part is missing in FL question that could lead to a different answer.  The question to us is not how to perform RLM in these cases, rather, should the specification require UE to perform RLM in all cases. According to the current specification we consider it may not be such case. And there is also gNB implementation to maintain the connectivity if RLM is not performed.  If a UE consider RLM is essential, why the UE report 6-1a for a BWP without SSB but also not support 1-7? The only expectation for network is that the UE may not perform RLM or can perform RLM based on implementation although ran1 spec does not require the UE to do so (RLM outside active BWP).  We also would like to clarify the situation but our view is that we may not always pursue the way by standard/spec especially considering what existing implementation can do and the implementations may be specifically allowed for flexibility. Rather, we could confirm that for such a UE what may be implemented and allowed and what gNB can do (i.e. can configure such operation with BWP without SSB). |
| CMCC | No | UE may either retuning to SSB for such measurement or be configured on a BWP with SSB. |

**2.BM**

Q2-1: Do you agree that a UE indicating support of FG6-1a (BWP without restriction) for a band without indicating support of SSB based BM and/or CSI-RS based BM (FG2-24) for the band? If no, please explain the interaction between FG6-1a and FG2-24.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | Yes | There is no prerequisite relation between FG6-1a and FG2-24. Therefore, a UE is allowed to indicate support of FG6-1a without support of SSB based BM and/or CSI-RS based BM.  Updating the descriptions such that CSI-RS based BM is a prerequisite for FG6-1a causes new restriction of operation and is a non-backward compatible change. |
| Ericsson | Yes | The formulation in the question is a bit strange. But the features are independent. |
| vivo | Unclear | Although we agree there is no dependency between FG6-1a and FG2-24 from the specification perspective, it is also the understanding from RAN1 specification that UE is not required to perform BM outside the active DL BWP. |
| Nokia, NSB | Yes | The features are independent. Running BM in all cells based on a DL RS is not a system requirement either. |
| Apple | Unclear | FG2-24 is Mandatory with capability signalling |
| ZTE | Yes | The features are independent. |
| NTT DOCOMO | Yes |  |
| CATT | Yes | FG 6-1a is independent with FG 2-24 |
| Samsung | Yes | There is no dependency between FG 6-1a and FG 2-24. |
| Vodafone | Yes | Similar view as Vivo |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |

Q2-2: If your answer to Q2-1 is yes, do you agree that for such UE, DL BWP that does not contain SSB can be configured and activated? Please explain why you think yes/no.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | Yes | It is specified in the description of FG6-1a that the active DL BWP may not contain SSB. If SSB shall be within the active DL BWP for such UE, the FG6-1a becomes useless. |
| Ericsson | Yes | The features are independent. |
| vivo | Yes but | DL BWP without SSB should be supported by the UE indicating support of FG6-1a, however, as commented above, it is unclear how UE perform BM in such case. |
| Nokia, NSB | Yes | The features are independent, DL RS based BM is not mandated by the RAN1 specs. |
| Apple | Unclear | Why CSI-RS cannot be used? |
| ZTE | Yes | The features are independent. |
| NTT DOCOMO | Yes | There are some scenarios where BM is not needed on a cell, e.g., cell with single beam operation. |
| CATT | Yes | Otherwise it is not a FG 6-1a, but a FG 6-1 instead. |
| Samsung | Yes | If a UE supports FG 6-1a, the UE can be configured with the DL BWP without SSB. |
| Vodafone | Yes |  |
| Huawei, HiSilicon | Yes |  |
| CMCC | It depends | Same as Q1-2. |

Q2-3: Do you agree that it is a valid scenario where a UE does not perform BM due to the lack of RS (SSB or CSI-RS) for BM in the active DL BWP? If yes, please explain in which condition(s) and for which UE such no-BM is valid. If no, please explain how BM is enabled for such case.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | No | It is not a valid scenario that BM is not enabled because of the lack of RS within the active DL BWP.   * If a UE supports FG6-1a and CSI-RS based BM, CSI-RS should be available within the DL BWP – therefore, this is not relevant to the question. * If a UE supports FG6-1a and SSB based BM but does not support CSI-RS based BM, CSI-RS within the DL BWP cannot be used for BM, and SSB may or may not be within the DL BWP. For such case, the UE shall be able to use SSB for BM even if it is not within the active DL BWP. * If a UE supports FG6-1a but does not support SSB based BM and CSI-RS based BM, there is no BM – therefore, this is not relevant to the question. |
| Ericsson | Yes | Again, the question is strange. The specification is clear, and the NW can configure CSI-RS in any BWP. |
| vivo |  | We think the question is a bit unclear. If the intention is to ask whether UE can work without RLM, our understanding is that it should be possible for a UE to not perform any BM. |
| Nokia, NSB | Yes | The RAN1 specifications do not require UE to be configured with BM resources. BM could be done based on SRS, or based on BM of another cell in a CA setup. |
| Apple | Yes | If gNB does not configure RS in the active BWP, gNB does not want to have BM based on DL RS.  If UE does not support CSI-RS based BM, gNB can configure SSB in the active BWP.  We feel we are just discussing assuming that some gNB just does not want to configure a NW to work properly. We doubt some commercial gNB would be that incapable. |
| ZTE | No | We share similar view as Qualcomm, i.e.,  *If a UE supports FG6-1a and SSB based BM but does not support CSI-RS based BM, CSI-RS within the DL BWP cannot be used for BM, and SSB may or may not be within the DL BWP. For such case, the UE shall be able to use SSB for BM even if it is not within the active DL BWP.* |
| NTT DOCOMO | Yes | There are some scenarios where BM is not needed on a cell, e.g., cell with single beam operation. |
| CATT | Yes, but | BM is not as essential as RLM. The UE may still work without BM.  But a UE may be capable to perform BM based on SSB outside its active BWP. |
| Samsung | Yes&No | We think the current spec does not preclude the case when BWP without SSB is configured based on reported FG 6-1a, and no RS for BM without FG 2-24. But similar with FG 1-7, FG 2-24 is also anyway mandatory feature (with capability signalling thou). |
| Vodafone | Unclear | We would prefer to have a clear specification (not up to implementation) on how to perform BM in the case there is lack of RS in the active DL BWP |
| Huawei, HiSilicon | Yes | Agree with Ericsson/Nokia/Apple.  Again the LS is also asking whether it is valid scenario in the standard. |
| CMCC | No | If the UE has to do BM then the answer is no, the same reason as Q1-3. However, if BM is not necessary, then it may be valid. |

**3.BFD**

Q3-1: Do you agree that a UE indicating support of FG6-1a (BWP without restriction) for a band without indicating support of SSB based BFD and/or CSI-RS based BFD (FG2-31) for the band?

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | Yes | There is no prerequisite relation between FG6-1a and FG2-31. Therefore, a UE is allowed to indicate support of FG6-1a without support of SSB based BFD and/or CSI-RS based BFD.  Updating the descriptions such that CSI-RS based BFD is a prerequisite for FG6-1a causes new restriction of operation and is a non-backward compatible change. |
| Ericsson | Yes |  |
| vivo | Unclear | Although we agree there is no dependency between FG6-1a and FG2-31 from the specification perspective, it is also the understanding from RAN1 specification that UE is not required to perform BFD outside the active DL BWP. |
| Nokia, NSB | Yes | The features are independent, configuring UE to do BFD is not mandated by the RAN1 specs. |
| Apple | Yes | Same as RLM |
| ZTE | Yes |  |
| NTT DOCOMO | Yes |  |
| CATT | Yes | FG 6-1a is independent with FG 2-31 |
| Samsung | Yes | There is no dependency between FG 6-1a and FG 2-31. |
| Vodafone | Yes | Similar view as vivo |
| Huawei, HiSilicon | Yes |  |
| CMCC | Yes |  |

Q3-2: If your answer to Q3-1 is yes, do you agree that for such UE, DL BWP that does not contain SSB can be configured and activated?

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | Yes | It is specified in the description of FG6-1a that the active DL BWP may not contain SSB. If SSB shall be within the active DL BWP for such UE, the FG6-1a becomes useless. |
| Ericsson | Yes |  |
| vivo | Yes but | DL BWP without SSB should be supported by the UE indicating support of FG6-1a, however, as commented above, it is unclear how UE perform BFD in such case. |
| Nokia, NSB | Yes |  |
| Apple | Yes |  |
| ZTE | Yes |  |
| NTT DOCOMO | Yes | There are some scenarios where BFD is not needed on a cell, e.g., cell with single beam operation. |
| CATT | Yes | Otherwise it is not a FG 6-1a, but a FG 6-1 instead. |
| Samsung | Yes | If a UE supports FG 6-1a, the UE can be configured with the DL BWP without SSB. |
| Vodafone | Yes |  |
| Huawei, HiSilicon | Yes |  |
| CMCC | It depends | The same reason as Q1-2. |

Q3-3: Do you agree that it is a valid scenario where a UE does not perform BFD due to the lack of RS (SSB or CSI-RS) for BFD in the active DL BWP? If yes, please explain in which condition(s) and for which UE such no-BFD is valid. If no, please explain how BFD is enabled for such case.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Qualcomm | No | It is not a valid scenario that BFD is not enabled because of the lack of RS within the active DL BWP.   * If a UE supports FG6-1a and CSI-RS based BFD, CSI-RS should be available within the DL BWP – therefore, this is not relevant to the question. * If a UE supports FG6-1a and SSB based BFD but does not support CSI-RS based BFD, CSI-RS within the DL BWP cannot be used for BFD, and SSB may or may not be within the DL BWP. For such case, the UE shall be able to use SSB for BFD even if it is not within the active DL BWP. * If a UE supports FG6-1a but does not support SSB based BFD and CSI-RS based BFD, there is no BFD – therefore, this is not relevant to the question. |
| Ericsson | Yes | Now the question is even stranger. BFD is an optional feature in the UE, and is configured by the NW. It is obviously a valid scenario not to configure an optional feature. |
| vivo |  | We think the question is a bit unclear. If the intention is to ask whether UE can work without RLM, our understanding is that it should be possible for a UE to not perform any BFD. |
| Nokia, NSB | Yes | There is no specification requirement to configure the UE with BFD resources to begin with, so it is a valid scenario for UE not performing BFD. |
| Apple | Yes | UE cannot be mandated to measurement RS outside active BWP for RLM/BFD unless there is some explicit UE feature  If gNB does not configure an active BWP with valid RS inside that active BWP for UE to perform RLM/BFD, it just means NW does not want to reply on RLM/BFD. UE should be forced to measure something outside active BWP. |
| ZTE |  | From our perspective, it would be good if UE can use SSB for BFD even if it is not within the active DL BWP in this case. |
| NTT DOCOMO | Yes | There are some scenarios where BFD is not needed on a cell, e.g., cell with single beam operation. |
| CATT | Yes, but | BFD is not as essential as RLM. The interoperation between UE and network still works without BFD.  But a UE may be capable to perform BFD based on SSB outside its active BWP. |
| Samsung | Yes&No | We think the current spec does not preclude the case when BWP without SSB is configured based on reported FG 6-1a, and no RS for BFD without FG 2-31. But similar with FG 1-7 and FG 2-24, FG 2-31 is anyway mandatory feature (with capability signalling thou) at least in FR2. |
| Vodafone | Unclear | We would prefer to have a clear specification (not up to implementation) on how to perform BFD in the case there is lack of RS in the active DL BWP |
| Huawei, HiSilicon | Yes |  |
| CMCC | No | If the UE has to do BFD then the answer is no, the same reason as Q1-3. However, if BM is not necessary, then it may be valid. |

# **2nd round discussion**

## **5.1 RLM**

The summary of 1st round discussion was following.

* 8 companies (Qualcomm, vivo, ZTE, DOCOMO(?), CATT, Samsung, Vodafone, CMCC) consider RLM for PCell is essential and it should not be possible to not perform RLM for PCell
* 4 companies (Ericsson, Nokia, Apple, Huawei) consider RLM for PCell is not enabled if RS for RLM is not within the active DL BWP
* All companies agree that a UE can indicate support of FG6-1a without indicating support of FG1-7, and such UE can be configured with active DL BWP that does not contain SSB
  + 4 companies (Qualcomm, ZTE, CATT, Vodafone) consider that SSB is used for RLM (for PCell) even if it is not within the active DL BWP
  + 4 companies (Ericsson, Nokia, Apple, Huawei) consider that RLM (for PCell) is not enabled if SSB is not in the active DL BWP for the UE

Note: it should be clear that here we are discussing RLM for PCell (not for SCell).

Q4-1: It is proposed to conclude the following. According to the inputs to Q1-1 and Q1-2, this should be the common understanding among almost all companies.

* A UE can indicate support of FG6-1a without indicating support of FG1-7. Such UE can be configured with active DL BWP that does not contain SSB.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Vodafone | Yes, but | The current standards allow it however, in our view, it goes against what is stated in the Stage 2 specifications and the contribution R2-2202229 clearly states it:  *9.2.7 Radio Link Failure*  *[…] 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.*  With this understanding, a clarification is required in the stage 2 on how to perform RLM measurements in an active DL BWP without SSB |
| Apple | No | Firstly: FG1-7 is “Mandatory with capability signalling”. This clarification essentially means “Mandatory with capability signalling” is the same as “Optional with capability signalling”. We understand that this is the reality, but do we need to confirm this in 3GPP?  Secondly: When UE support FG6-1a, it does not mean gNB cannot configure active BWP that contains SSB. If NW believes RLM is very crucial, NW can configure active BWP that contains SSB.  Lastly, we need to discuss when it is P(S)Cell or SCell. The issue, if there is any, is mostly for P(S)Cell  .  In our view, why do we need to spend time discussing some bad NW configuration, i.e., NW believes RLM is crucial, but NW does not want to configure RLM RS in the active BWP. In our view, if NW made that configuration, they believe RLM is not important for P(S)Cell. We may disagree during field trial, but there are many ways for NW to configure a system that does not work. |
| Ericsson | Yes | This seems obvious: the UE is not configured beyond its capabilities, so clearly the configuration is possible.  We agree with Apple – this discussion seems pointless. It is clear what the specification supports. |
| Qualcomm | Yes |  |
| Huawei, HiSilicon | Yes | In addition to Apple comment that NW can make proper configuration, the situation that UE report as such also means it is doable.  We do not prefer to remove  *For other DL BWPs, RLM can only be performed based on CSI-RS.*  Since this above is a standard approach for other BWPs. For a BWP without SSB, how RLM is done is unknown to gNB and no requirements. |
| CATT | Yes | We think it is true that ‘A UE can be configured with active DL BWP that does not contain SSB if it indicates support of FG6-1a’. It is allowed in the spec.  However, we have similar confusion as Apple since FG1-7 is ‘Mandatory with capability signalling’. |
| NTT DOCOMO |  | We are fine with the first part below.  “A UE can indicate support of FG6-1a without indicating support of FG1-7.”  However, for the second part below, we think it depends on whether we can agree on either (1) or (2) in Q4-2.  “Such UE can be configured with active DL BWP that does not contain SSB.”  If we can agree on neither (1) nor (2) in Q4-2, the conclusion is such UE cannot be configured with active DL BWP that does not contain SSB for P(S)Cell, while such UE can be configured with active DL BWP that does not contain SSB for SCell.  As FG6-1a is per-band reporting, it is still meaningful for SCell even when the UE does not report the support of FG1-7 and the configuration is not allowed for P(S)Cell. |
| vivo | Clarification | We agree with that UE can indicate FG6-1a while not FG1-7 and accordingly such UE can be configured with DL BWP without SSB.  However, the current specification does not provide a solution for such a UE to work (e.g. RLM), which means such case may not be valid configuration according to current specification. |
| Samsung | Yes |  |
| Nokia, NSB | Yes | The UE can do this. We do agree with Apple that the UE should not do this, but the specification does still allow it. |
| ZTE | Yes |  |
| MediaTek | No | Sorry for joining the discussion really late. I hope our views can still be taken into account.  Firstly, FG 1-7 is ***mandatory*** with capability signalling and not optional. It hence should be supported by UE (sooner or later).  Secondly, as quoted in the RAN2 LS, TS38.300 clearly says “For other DL BWPs, RLM can only be performed based on CSI-RS.” If a UE cannot support FG 1-7, it should not indicate FG6-1a in the first place. And we don’t agree what RAN2 says in the LS that UE does not report CSI-RS based RLM/BM (FG1-7 and 2-24) because both are mandatory in our view (though with capability signaling). |

Q4-2: For such UE, there are two views: (1) RLM based on SSB is enabled even if SSB is not within the active DL BWP, and (2) RLM is not enabled if SSB is not within the active DL BWP. It would be good to continue some more discussion on this aspect.

* Please indicate your understanding (1) or (2) and elaborate the reasons.
  + If you select (1), please explain what the problem is with (2).
  + If you select (2), please explain what the problem is with (1).

|  |  |  |
| --- | --- | --- |
| Company | (1) or (2) | Comment |
| Vodafone | (1) | In order to not create NBC issues by adding prerequisite relation between FG6-1a and FG1-7, our preference is option (1) which would require Stage 2 modifications and such update should be highlighted to RAN2. |
| Apple | (2) | UE is not required to measure RS outside active BWP.  A problematic NW configuration, i.e., do not configure RLM RS in active BWP but still want UE to perform RLM, cannot be used to force UE to break the above rule. |
| Ericsson | (2) | According to the specification, the UE is not required to monitor radio link quality in another DL BWP than the active DL BWP, which is a “problem” with (1) |
| Qualcomm | (1) | Agree with Vodafone.  Regarding the RAN1 specification sentence TS38.213 “*The UE is not required to monitor the downlink radio link quality in DL BWPs other than the active DL BWP, as described in clause 12, on the primary cell*”, our view is that this does not mean RLM-RS shall be within the active DL BWP. Our understanding is that the hypothetical PDCCH for computing in-sync/out-sync BLER is the one within the active DL BWP. RAN4 specifies requirements for SSB based RLM when SSB is transmitted within active DL BWP. However, this is a separate and RAN4’s issue.  Having said that, there is no obstacle for a UE supporting FG6-1a but not supporting FG1-7, other than the description in TS38.300 Stage-2 spec, to perform RLM using SSB that is not within the active DL BWP. As the outcome of the discussion of this thread, we also would like to propose to let RAN2 to fix the description in TS38.300, so that such UE is able to use the SSB for RLM. |
| Huawei, HiSilicon | (1)&(2) | Both are possible and is unknown to gNB (like legacy).   * (1) is possible by UE implementation, especially this is a non-RedCap UE.   + The problem with (2) is the potential performance degradation. * (2) is possible if a UE decide not to do so. Note a UE is not required to do measurement by standard does not mean UE will not do. The potential problem with (1) is that gNB does not know what implementation approach is used by UE, e.g. open its RF or RF retuning.   We do not prefer to remove  *For other DL BWPs, RLM can only be performed based on CSI-RS.*  Since this above is a standard approach for other BWPs. For a BWP without SSB, how RLM is done is unknown to gNB and no requirements.  Overall, the situation is allowed by standard while the main issue to us is how much impact on performance by such (UE report so and gNB does not know which of (1) and (2)). We think proper test in RAN4 on FG 6-1a would be helpful, and CSI-RS can be an easier approach if performance impact is unsure.  Nonetheless, it would also be good to clarify that UE implementation for measurement is possible. |
| CATT | (1) | We cannot see how the UE can work without RLM.  But we do feel this is a corner case. Both UE and network act strange: (a) The UE is indicating it is capable to work without SSB but cannot perform CSI-RS-based RLM. (b) The network forces the UE to perform SSB-based RLM outside its active BWP deliberately.  Again such contradictory case can be easily avoided by implementation, e.g. by configuring the BWP to contain SSB. |
| NTT DOCOMO | (1)or(3) | As this is about PCell, (2) is not acceptable as RLM is essential feature.  We are ok with (1) if majority is also ok.  If we cannot agree on (1), the conclusion (called as (3)) should be that such UE cannot be configured with active DL BWP that does not contain SSB for P(S)Cell, while such UE can be configured with active DL BWP that does not contain SSB for SCell. |
| vivo | (2) | Agree with Apple and Ericsson.  (1) is not consistent with TS38.300 and TS38.213. |
| Samsung | (2) | As in the current specification, the UE is not required to measure RS outside active BWP. |
| Nokia, NSB | (2) | **SSB-based RLM is not enabled,** and if the UE doesn’t support 1-7, then RLM is cannot be done with CSI-RS either. We can’t expect the UEs to measure SSB outside the active BWP. We would not mind this being supported, but we can’t make this assumption based on the FG 6-1a. Notably the UE could also retune its Rx (and Tx) filters and have better out-of-BWP isolation. |
| ZTE | (1) | Although we agree that both (1) and (2) are possible. However, from network perspective, (1) is our preference. Again, even in this case, network still would like UE to perform RLM. |
| MediaTek | (2) | The specification clearly says that UE is not required to measure RS outside of active BWP. RLM is very essential to UE mobility. We don’t expect UE to operate on BWP w/o any RS for RLM. |

## **5.2 BM**

The summary of 1st round discussion was following.

* 11 companies (Qualcomm, Ericsson, vivo, Nokia, ZTE, DOCOMO, CATT, Samsung, Vodafone, Huawei, CMCC) agree that FG6-1a and FG2-24 are independent features. Regardless of whether the UE supports SSB based BM and/or CSI-RS based BM, the UE can indicate support of FG6-1a.

There seems some misunderstanding regarding the questions.

* As copied in the Annex and as explained in Section 2, SSB based BM and CSI-RS based BM are not mandatory for some cases.
* Suppose a UE supporting FG6-1a indicates support of SSB based BM (but not CSI-RS based BM):
  + If such UE is configured with active DL BWP that does not contain SSB, the question is whether it is possible to use the SSB for the BM.
* Of course, if the UE supporting FG6-1a does not indicate support of SSB based BM and CSI-RS based BM, any BM is not applicable to the UE on the band.

Q5-1: It is proposed to conclude the following. According to Q2-1 and Q2-2, this should be the majority’s understanding.

* A UE can indicate support of FG6-1a with or without support for SSB based BM and/or CSI-RS based BM.
* A UE supporting FG6-1a and SSB based BM without support of CSI-RS based BM can be configured with active DL BWP that does not contain SSB.

|  |  |  |
| --- | --- | --- |
| Company | Yes/No | Comment |
| Vodafone | Yes, but | The current standards allow it however, in our view, it goes against what is stated in the Stage 2 specifications and the contribution R2-2202229 clearly states it:  *9.2.3.1 Overview*  *[…] SSB-based Beam Level Mobility is based on the SSB associated to the initial DL BWP and can only be configured for the initial DL BWPs and for DL BWPs containing the SSB associated to the initial DL BWP. For other DL BWPs, Beam Level Mobility can only be performed based on CSI-RS.*  With this understanding, a clarification is required in the stage 2 on how to perform BM measurements in an active DL BWP without SSB |
| Apple | No | Similar comment as RLM. FG2-24 is “Mandatory with capability signalling”.  Furthermore, we need to clarification on how UE can report UE supports SSB based BM, but does not support CSI-RS based BM. UE either supports both which is “Mandatory with capability signalling”, or none |
| Ericsson | Yes | We note that supporting CSI-RS-based L1-RSRP measurements is mandatory in FR1. But in principle, it’s possible to have a UE that supports only L1-RSRP measurements on SSB in FR2. And again – as long as the NW does not configure the UE beyond its capabilities, the configuration is possible. |
| Qualcomm | Yes | @Apple: In the standard, a UE can report supporting SSB based BM but not supporting CSI-RS based BM. Please check TS38.306 (or Annex below). |
| Huawei, HiSilicon | Yes but | More useful to clarify what is possible even if it is not in the standard, i.e. UE implementation can aid such UE for measurement, and ask for some more work in RAN4 to properly test the impact of performance. |
| CATT | Yes |  |
| NTT DOCOMO | Yes |  |
| vivo | No | Similar question as Apple, the existing FG 2-24 covers both SSB and CSI-RS based BM, UE can either support both or none, but seems not possible to support only one. |
| Samsung | Yes |  |
| Nokia, NSB | Yes |  |
| ZTE | Yes |  |
| MediaTek | No | Same reasons as explained in our reply to the previous question.  Like FG1-7 (CSI-RS based RLM), FG 2-24 is **mandatory** (though with capability signalling). UE should support it (sooner or later). Otherwise, it should have agreed as an optional feature.  In addition, agree with Apple that FG2-24 includes both SSB and CSI-RS. UE should support both and not just one of them. |

Q5-2: For a UE supporting FG6-1a and SSB based BM but not supporting CSI-RS based BM, considering the discussion for RLM, there would be two views: (1) SSB based BM is enabled even if SSB is not within the active DL BWP, and (2) SSB based BM is not enabled if SSB is not within the active DL BWP. It would be good to continue some more discussion on this aspect.

* Please indicate your understanding (1) or (2) and elaborate the reasons.
  + If you select (1), please explain what the problem is with (2).
  + If you select (2), please explain what the problem is with (1).

|  |  |  |
| --- | --- | --- |
| Company | (1) or (2) | Comment |
| Vodafone | (1) | Same reasoning as in Q4-2 |
| Apple | (2) | BM cannot reply on measurement outside active BWP. |
| Ericsson | (2) | The UE is not required to perform L1 measurements on reference signals outside its active DL BWP |
| Qualcomm | (1) | Similar to RLM, our understanding is that there is no obstacle for a UE supporting FG6-1a and SSB based BM but not supporting CSI-RS based BM, other than the description in TS38.300 Stage-2 spec, to perform SSB based BM using SSB that is not within the active DL BWP. As the outcome of the discussion of this thread, we also would like to propose to let RAN2 to fix the description in TS38.300, so that such UE is able to use SSB for BM. |
| Huawei, HiSilicon | (1)&(2) | Similar response. |
| CATT | (2) | Other ways may be used for BM in this case, e.g. using UL signal. |
| NTT DOCOMO | (1)or(2) | If (1) is agreed for RLM, the same handling can be applied to BM. Otherwise, (2) should be applied to BM. |
| vivo | (2) | (1) is not consistent with the current specification, e.g. TS38.133 section 9.5.1 has the following  When configured by the network, the UE shall be able to perform L1-RSRP measurements of configured CSI-RS, SSB or CSI-RS and SSB resources for L1-RSRP. The measurements shall be performed for a serving cell, including PCell, PSCell, or SCell, on the resources configured for L1-RSRP measurements within the active BWP. |
| Samsung | (2) | Similar reason in RLM. The UE is not required to perform beam management operation by reference signals outside the active DL BWP. |
| Nokia, NSB | (2) | Same as with RLM. We would not mind UEs being able to do BM based on SSB (or CSI-RS) outside the active BWP, but the current FGs can’t be assumed to indicate that. |
| ZTE | (1) | Similar response |
| MediaTek | (2) | Agree with Apple that BM cannot rely on measurements outside of active BWP. |

## **5.2 BFD**

The summary of 1st round discussion was following.

* 11 companies (Qualcomm, Ericsson, vivo, Nokia, ZTE, DOCOMO, CATT, Samsung, Vodafone, Huawei, CMCC) agree that FG6-1a and FG2-31 are independent features. Regardless of whether the UE supports SSB based BFD and/or CSI-RS based BFD, the UE can indicate support of FG6-1a.

There seems some misunderstanding regarding the status and question.

* As copied in the Annex and as explained in Section 2, SSB based BFD and CSI-RS based BFD are not mandatory for some cases.
* Suppose a UE supporting FG6-1a indicates support of SSB based BFD (but not CSI-RS based BFD):
  + If such UE is configured with active DL BWP that does not contain SSB, the question is whether it is possible to use the SSB for the BFD.
* Of course, if the UE supporting FG6-1a does not indicate support of SSB based BFD and CSI-RS based BFD, any BFD is not applicable to the UE on the band.

Q6-1: It is proposed to conclude the following. According to the inputs to Q3-1 and Q3-2, this should be the majority’s understanding.

* A UE can indicate support of FG6-1a with or without support for SSB based BFD and/or CSI-RS based BFD.
* A UE supporting FG6-1a and SSB based BFD without support of CSI-RS based BFD can be configured with active DL BWP that does not contain SSB.

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| --- | --- | --- |
| Company | Yes/No | Comment |
| Vodafone | Yes, but | The current standards allow it however, in our view, it goes against what is stated in the Stage 2 specifications and the contribution R2-2202229 clearly states it:  *9.2.8 Beam failure detection and recovery*  *[…] SSB-based Beam Failure Detection is based on the SSB associated to the initial DL BWP and can only be configured for the initial DL BWPs and for DL BWPs containing the SSB associated to the initial DL BWP. For other DL BWPs, Beam Failure Detection can only be performed based on CSI-RS.*  With this understanding, a clarification is required in the stage 2 on how to perform BFD measurements in an active DL BWP without SSB |
| Apple | No | Similar as BM. FG2-31 is “Mandatory with capability signalling” for FR2 |
| Ericsson | Yes | Again, this seems obvious: the UE is not configured beyond its capabilities, so clearly the configuration is possible. |
| Qualcomm | Yes | @Apple, as pointed out in the background and as you mentioned in your reply to Q4-1, Mandatory with capability signalling means it is mandatory but whether it is enabled or not depends on the capability signalling. This is a common exercise and we do not need to discuss this here. |
| Huawei, HiSilicon | Yes but | Similar response. |
| CATT | Yes |  |
| NTT DOCOMO | Yes |  |
| vivo | No | Similar issue as for BM, existing 2-31 covers both SSB and CSI-RS based BFD, UE cannot indicate to support only one of them. |
| Samsung | Yes |  |
| Nokia, NSB | Yes |  |
| ZTE | Yes |  |
| MediaTek | No | As pointed out by Apple, FG 2-31 is **mandatory** with capability signalling for FR2. |

Q5-2: For a UE supporting FG6-1a and SSB based BM but not supporting CSI-RS based BM, considering the discussion for RLM, there would be two views: (1) SSB based BM is enabled even if SSB is not within the active DL BWP, and (2) SSB based BM is not enabled if SSB is not within the active DL BWP. It would be good to continue some more discussion on this aspect.

* Please indicate your understanding (1) or (2) and elaborate the reasons.
  + If you select (1), please explain what the problem is with (2).
  + If you select (2), please explain what the problem is with (1).

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| --- | --- | --- |
| Company | (1) or (2) | Comment |
| Vodafone | (1) | Same reasoning as Q4-2 |
| Apple | (2) | Let us make one more summary regarding the issue discussed here for RLM/BM/BFD  When NW wants UE to perform RLM/BFD/BM in an active BWP, NW needs to provide UE with RS in the active BWP. From UE perspective, our capability will indicate we support at least one of the RS, SSB or CSI-RS, measured in active BWP.  We should not discuss a NW behaviour that NW wants UE to perform RLM/BFD/BM, but NE does not provide UE with any RS in the active BWP that UE can process. Consequently, forcing UE to perform measurement outside active BWP.  Unless there is compelling reason which we fail to recognize, otherwise, in our view, this is a very unreasonable NW. We already report our capability to make a reasonable deployment possible. We do not want to encourage some unreasonable deployment and make any conclusion in 3GPP to endorse that configuration. |
| Ericsson | (2) | The UE is not required to perform BFD outside the active BWP.  We very much agree with Apple. Furthermore, NR provides the possibility to configure CSI-RS in BWPs where there is no SSB – for exactly this purpose. |
| Qualcomm | (1) | Similar to RLM, our understanding is that there is no obstacle for a UE supporting FG6-1a and SSB based BFD but not supporting CSI-RS based BFD, other than the description in TS38.300 Stage-2 spec, to perform SSB based BFD using SSB that is not within the active DL BWP. As the outcome of the discussion of this thread, we also would like to propose to let RAN2 to fix the description in TS38.300 so that such UE is able to use SSB for BFD. |
| Huawei, HiSilicon |  | Similar response and does not prefer to ask RAN2 change anything that is in the standard, since the main interest here is what/whether UE may implement outside standard.  Also repeat and agree that CSI-RS is another approach that can ease the issue although we understand what may not be supported by spec. |
| CATT | (2) | In fact, it is not surprised if UE will do nothing for BFD due to the lack of proper RS within the active BWP. The network should be aware of this. |
| NTT DOCOMO | (1)or(2) | If (1) is agreed for RLM, the same handling can be applied to BFD. Otherwise, (2) should be applied to BFD. |
| vivo | (2) | (1) is not consistent with the existing specification, e.g. TS38.133 section 8.5.1 has the following  The RS resource configurations in the set  on PCell or PSCell can be periodic CSI-RS resources and/or SSBs. RS resource configuration in the set  on SCell shall be periodic CSI-RS. UE is not required to perform beam failure detection outside the active DL BWP. |
| Samsung | (2) | Similar reason in RLM and BM. |
| Nokia, NSB | (2) | Same reason as in RLM and BM |
| ZTE | (1) | Similar reasons. |
| MediaTek | (2) | In our view, the identified FGs (FG1-7, 2-24, 2-31) by RAN2 are basically all **mandatory** with capability signalling (except for 2-31 BFD in FR1). And they should be supported by UE correspondingly. In addition, TS38.300 has clearly said that if UE operates on a BWP w/o SSB, RLM/BFD/Beam Level Mobility can be only performed based on CSI-RS.  We hence don’t agree that a UE can indicate the support for FG6-1a without indicating the support for FG1-7, 2-24, and 2-31 (except 2-31 in FR1). |

# **3rd round discussion**

3rd round discussion has been carried out using the email thread [109-e-AI5-LSs-01] focusing on RLM. To address the situation where companies have diverged views on how to answer Q1 of RAN2 LS, we have been looking into some more details on how/whether a UE supporting FG6-1a but not supporting CSI-RS based RLM does RLM. Moderator summarizes the options presented so far by companies as follows.

* Opt.1: RLM is not required (or is not expected)
* Opt.2: Active DL BWP is configured to contain SSB
* Opt.3: RLM is enabled by using SSB that can be outside the active DL BWP

If we agree Opt.1, then the answer to Q1 should be “Yes”. If we agree Opt.2, then the answer to Q2 should be “based on SSB within active DL BWP” (answer to Q1 can be yes or no). If we agree Opt.3, then the answer to Q2 should be “based on SSB that is within or outside active DL BWP” (answer to Q1 can be yes or no).

Regarding Opt.1, moderator brought up a question on how a UE shall behave when “RLM is not required (or is not expected)”. The UE has to monitor RLM for out-of-sync/in-sync and declare RLF if conditions are met. However, with Opt.2, the UE does not monitor RLM and hence, it is not clear when/whether/how RLF is declared. It is moderator’s understanding that it is not possible to “disable” RLM for PCell.

However, Opt.2 guarantees the UE behavior. Therefore, some companies consider that if RLM is an important matter, gNB should configure active DL BWP such that it contains SSB. On the other hand, it is argued that this effectively disables BWP without restriction (FG6-1a).

Regarding Opt.3, there are discussions whether this is aligned with the RAN1 understanding/specifications. Some companies consider this is not inconsistent with RAN1 specs, while other companies consider this is.

To address the situation that companies cannot be converged, there is a proposal to introduce new Rel-16 UE capability, FG6-1b, to enable a UE indicating support of BWP without restriction using SSB that is within/outside active DL BWP for RLM/BM/BFD. This is intended to address the concern on Opt.3 (may not be aligned with the understanding/spec) and on Opt.2 (FG6-1a cannot be BWP without restriction).

Please indicate if you think something in the above is not correct.

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| --- | --- |
| Company | Comment |
| vivo | Fine in general. and our understanding is such summary is for RAN1 internal use and will not be sent to RAN2/4, right?  There might be one typo as below  Regarding Opt.1, moderator brought up a question on how a UE shall behave when “RLM is not required (or is not expected)”. The UE has to monitor RLM for out-of-sync/in-sync and declare RLF if conditions are met. However, with Opt.2, the UE does not monitor RLM and hence, it is not clear when/whether/how RLF is declared. It is moderator’s understanding that it is not possible to “disable” RLM for PCell. |
| Vodafone | Our preference is Opt.3 while reusing FG 6-1a and highlighting this change to RAN2 in order align Stage 2 specifications (adding a new capability would require modifications as well). We believe that such solution is already deployed in current devices supporting FG6-1a and would make the UE behavior clearer within the standard.  We also don’t understand the meaning of “if RLM is an important manner”, in which scenarios is RLM not an important manner? Are those scenarios a corner case in current deployments? |
|  |  |

# **Proposals & draft LS reply**

Considering that many companies, including multiple operators, consider RLM is essential for PCell, moderator would like to propose not to leave the issue as is. On the other hand, it is now true that there are companies having concern or problem to state a UE supporting FG6-1a is able to perform RLM/BM/BFD using SSB not within active DL BWP. With these in mind, moderator would like to propose to take the approach of introducing new UE capability indicating support of RLM/BM/BFD using SSB not within active DL BWP.

**Proposal 1:**

* Introduce new Rel-16 UE capability(ies) for BWP operation without restriction with SSB that is within or outside the active DL BWP for RLM/BM/BFD
  + FFS: capability(ies) details and RAN1 spec impact (if any) until RAN1#110
  + Inform the decision to RAN2/RAN4

With the above, draft LS reply to RAN2 could be as following.

**Proposal 2:**

* Agree following draft LS reply to RAN2.

|  |
| --- |
| **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]: RAN1 did not reach consensus on whether the current standard supports the operation of BWP without SSB where the UE does not perform BM/RLM/BFD due to the lack of RS in the active DL BWP. However, RAN1 agreed to introduce new R16 UE capability(ies) that indicates the UE supports operation of BWP without SSB where BM/RLM/BFD is based on SSB. RAN1 will inform RAN2 more details once it is consolidated.  **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]: See RAN1’s answer to Question 1. |

Any comment?

|  |  |
| --- | --- |
| Company | Comment |
| vivo | Fine with the text above. In addition we think RAN1 should also ask RAN4 to decide how the UE with new capability is supposed to perform BM/RLM/BFD based on SSB outside active DL BWP, e.g. by using a larger RF BW, and also the related impact to performance requirement, if any. |
| Vodafone | If majority view is to have a new capability, we are fine with the text above. We agree with vivo that further details on how the measurements are done based on SSB outside active DL BWP. |
|  |  |

# **Summary and conclusion**

TBA

# **Reference**

1. R1-2203043 LS on BWP operation without bandwidth restriction RAN2, Qualcomm
2. R1-2203494 Draft Reply LS on BWP operation without bandwidth restriction vivo
3. R1-2203846 Draft reply LS on BWP operation without bandwidth restriction Samsung
4. R1-2204272 Discussion on RAN2 LS on BWP operation without bandwidth restriction CMCC
5. R1-2204331 [Draft] Reply LS on BWP operation without bandwidth restriction ZTE
6. R1-2204333 Discussion on BWP operation without bandwidth restriction NTT DOCOMO, INC.
7. R1-2204920 Discussion on BWP operation without bandwidth restriction Huawei, HiSilicon
8. R1-2204971 Discussion on RAN2 LS on BWP operation without bandwidth restriction Qualcomm Incorporated
9. R1-2204035 Discussion of BWP operation without bandwidth restriction Ericsson

# **Annex: Relevant UE capability signalling**

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| Definitions for parameters | Per | M | FDD-TDD DIFF | FR1-FR2 DIFF |
| ***csi-RS-RLM (FG1-7)***  Indicates whether the UE can perform radio link monitoring procedure based on measurement of CSI-RS as specified in TS 38.213 [11] and TS 38.133 [5]. This parameter needs FR1 and FR2 differentiation. If the UE supports this feature, the UE needs to report *maxNumberResource-CSI-RS-RLM*. This applies only to non-shared spectrum channel access. For shared spectrum channel access, *csi-RS-RLM-r16* applies. | UE | Yes | No | Yes |
| ***ssb-AndCSI-RS-RLM (FG1-8)***  Indicates whether the UE can perform radio link monitoring procedure based on measurement of SS/PBCH block and CSI-RS as specified in TS 38.213 [11] and TS 38.133 [5]. If the UE supports this feature, the UE needs to report *maxNumberResource-CSI-RS-RLM*. This applies only to non-shared spectrum channel access. For shared spectrum channel access, *ssb-AndCSI-RS-RLM-r16* applies. | UE | No | No | No |
| ***beamManagementSSB-CSI-RS (FG2-24)***  Defines support of SS/PBCH and CSI-RS based RSRP measurements. The capability comprises signalling of  - *maxNumberSSB-CSI-RS-ResourceOneTx* (component 1) indicates maximum total number of configured one port NZP CSI-RS resources and SS/PBCH blocks that are supported by the UE to measure L1-RSRP as specified in TS 38.215 [13] within a slot and across all serving cells (see NOTE). On FR2, it is mandatory to report >=8; On FR1, it is mandatory with capability signalling to report >=8.  - *maxNumberCSI-RS-Resource* (component 2) indicates maximum total number of configured NZP-CSI-RS resources that are supported by the UE to measure L1-RSRP as specified in TS 38.215 [13] across all serving cells (see NOTE). It is mandated to report at least n8 for FR1.  - *maxNumberCSI-RS-ResourceTwoTx* (component 3) indicates maximum total number of two ports NZP CSI-RS resources that are supported by the UE to measure L1-RSRP as specified in TS 38.215 [13] within a slot and across all serving cells (see NOTE).  - *supportedCSI-RS-Density* (component 4) indicates density of one RE per PRB for one port NZP CSI-RS resource for RSRP reporting, if supported. On FR2, it is mandatory to report either "three" or "oneAndThree"; On FR1, it is mandatory with capability signalling to report either "three" or "oneAndThree".  - *maxNumberAperiodicCSI-RS-Resource* (component 5) indicates maximum number of configured aperiodic CSI-RS resources across all serving cells (see NOTE). For FR1 and FR2, the UE is mandated to report at least n4.  NOTE: If the UE sets a value other than *n0* in an FR1 band, it shall set that same value in all FR1 bands. If the UE sets a value other than *n0* in an FR2 band, it shall set that same value in all FR2 bands. The UE supports a total number of resources equal to the maximum of the FR1 and FR2 value, but no more than the FR1 value across all FR1 serving cells and no more than the FR2 value across all FR2 serving cells. | Band | Yes | N/A | FD |
| ***maxNumberCSI-RS-BFD (FG2-31 component 1)***  Indicates maximal number of CSI-RS resources across all CCs, and across MCG and SCG in case of NR-DC, for UE to monitor PDCCH quality. In this release, the maximum value that can be signalled is 16. If the UE includes the field in an FR1 band, it shall set the same value in all FR1 bands. If the UE includes the field in an FR2 band, it shall set the same value in all FR2 bands. The UE supports a total number of resources equal to the maximum of the FR1 and FR2 value, but no more than the FR1 value across all FR1 serving cells and no more than the FR2 value across all FR2 serving cells. It is mandatory with capability signalling for FR2 and optional for FR1. | Band | CY | N/A | N/A |
| ***maxNumberSSB-BFD (FG2-31 component 2)***  Defines maximal number of different SSBs across all CCs, and across MCG and SCG in case of NR-DC, for UE to monitor PDCCH quality. In this release, the maximum value that can be signalled is 16. If the UE includes the field in an FR1 band, it shall set the same value in all FR1 bands. If the UE includes the field in an FR2 band, it shall set the same value in all FR2 bands. The UE supports a total number of resources equal to the maximum of the FR1 and FR2 value, but no more than the FR1 value across all FR1 serving cells and no more than the FR2 value across all FR2 serving cells. It is mandatory with capability signalling for FR2 and optional for FR1. | Band | CY | N/A | N/A |
| ***maxNumberCSI-RS-SSB-CBD (FG2-31 component 3)***  Defines maximal number of different CSI-RS [and/or SSB] resources across all CCs, and across MCG and SCG in case of NR-DC, for new beam identifications. In this release, the maximum value that can be signalled is 128. If the UE includes the field in an FR1 band, it shall set the same value in all FR1 bands. If the UE includes the field in an FR2 band, it shall set the same value in all FR2 bands. The UE supports a total number of resources equal to the maximum of the FR1 and FR2 value, but no more than the FR1 value across all FR1 serving cells and no more than the FR2 value across all FR2 serving cells. It is mandatory with capability signalling for FR2 and optional for FR1. The UE is mandated to report at least 32 for FR2. | Band | CY | N/A | N/A |
| ***bwp-WithoutRestriction (FG6-1a)***  Indicates support of BWP operation without bandwidth restriction. The Bandwidth restriction in terms of DL BWP for PCell and PSCell means that the bandwidth of a UE-specific RRC configured DL BWP may not include the bandwidth of CORESET #0 (if configured) and SSB. For SCell(s), it means that the bandwidth of DL BWP may not include SSB. | Band | No | N/A | N/A |