**3GPP TSG-RAN WG4 Meeting # 95-e R4-200xxxx**

**Electronic Meeting, 25 May– 5 June, 2020**

**Agenda item:** 6.16.1.3 /6.16.1.4

**Source:** Moderator (OPPO)

**Title:** Email discussion summary for [95e][226]NR\_CSIRS\_L3meas\_RRM\_2

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion and provide some guidelines for email discussion if necessary.*

For measurement capability, 6 sub-topics are identified and to be discussed in this meeting.

* *Sub-topic 1-1: General*
* *Sub-topic 1-2: number of frequency layers to be monitored*
* *Sub-topic 1-3: number of cells to be monitored*
* *Sub-topic 1-4: number of CSI-RS resource/beams to be monitored per layer/MO*
* *Sub-topic 1-5: Buffering and processing capability*
* *Sub-topic 1-6: On CSI-RS resources configurations*

For measurement requirement, 6 sub-topics are identified and to be discussed in this meeting.

* *Sub-topic 2-1: General*
* *Sub-topic 2-2: Measurement delay*
* *Sub-topic 2-3: Scaling factor*
* *Sub-topic 2-4: UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell*
* *Sub-topic 2-5: Scheduling Restriction*

*List of candidate target of email discussion for 1st round and 2nd round*

* *1st round: Discuss and agree on all listed issues for measurement capability and measurement requirement.*
* *2nd round: Discuss and agree on CRs，and provide the WF for both agreements and remaining open issues.*

# Topic #1: Measurement capability

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2006225**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006225.zip) | CATT | **Proposal 1: CSI-RS based UE measurement capabilities shall specified in terms of:*** **Number of carrier to be monitored**
* **Number of cell to be monitored per frequency layer**
* **Number of CSI-RS resources to be monitored per frequency layer**

**Proposal 2: UE shall be able to measure at least 8 NR frequency layers in total, including SSB frequency layers and CSI-RS frequency layers.****Proposal 3: UE shall be able to measure at least 14 carriers of all RATs in total.****Proposal 4: The requirement of number of cell to be monitored defined for SSB based UE measurement capability can be reused to define the number of cells to be monitored for CSI-RS based UE measurement capabilities.****Proposal 5: For the number of CSI-RS resource, UE shall monitor at least 24 CSI-RS resources per frequency layer.** |
| [**R4-2006552**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006552.zip) | Intel Corporation | ***Proposal 1:*** ***measurement capability requirement is defined per frequency layer for CSI-RS based measurement.******Proposal 2:*** ***the frequency layer definition for CSI-RS is as follows:***

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| * ***the same SCS and CP type***
* ***the same centre frequency***
* ***the same value of CSI-RS bandwidth***
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***Proposal 3: Considering the flexibility of CSI-RS, more configuration options of CSI-RS than that of SSB can be designed.*** |
| [**R4-2006574**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006574.zip) | MediaTek inc. | **Proposal 1:** **One MO is one frequency layer. Different MOs are different frequency layers.****Proposal 2: The layers to be monitored based on CSI-RS can only be a subset of the layers to be monitored based on SSB. The minimum # of layers to be measured based on CSI-RS is the same as that for** SSB.**Proposal 3: The cells to be monitored based on CSI-RS can only be a subset of the cells to be monitored based on SSB. The minimum # of cells to be measured based on CSI-RS is the same as that** for**Proposal 4: If the number of remaining CSI-RS resources to be measured with detectable associated SSB in an MO is larger than the UE measurement capability, the UE behavior is undefined.****Proposal 5: Regarding the number of CSI-RS (beams) to be monitored per layer based on L3 CSI-RS, requirements defined the same requirements as those for SSB.****Proposal 6: Since only requirements with associated SSB will be defined, the UE processing capability in a slot per MO should be revised to consider only the CSI-RS resources to be measured with detectable associated SSB.****Proposal 7: The discussion of UE buffering and processing capability is pending on the conclusion of time domain limitation of the CSI-RS per MO in another discussion.** |
| [**R4-2006764**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006764.zip) | CMCC | ***Observation 1: the associated SSB used for CSI-RS measurement may not be the same as the SSB configured as mobility RS in MO, which will increase the number of frequency layers UE need to measure.*** ***Proposal 1: it is proposed that UE is capable of measuring [8] NR frequency layers including SSB frequency layers configured as mobility RS in MO and associated SSB used for CSI-RS measurement******Proposal 2: For each intra-frequency layer, it is proposed that UE is capable of measuring [8] CSI-RS cell for FR1 and [6] CSI-RS cells for FR2.******Proposal 3: For each inter-frequency layer, it is proposed that UE is capable of measuring [4] CSI-RS cell for both FR1 and FR2.******Proposal 4: For each intra-frequency layer for FR1, the number of CSI-RS resource is proposed to be [32]. For each intra-frequency layer for FR2, the number of CSI-RS resource is proposed to be [42]******Proposal 5: For each inter-frequency layer for FR1, the number of CSI-RS resource is proposed to be [24]. For each inter-frequency layer for FR2, the number of CSI-RS resource is proposed to be [34]*** |
| [**R4-2007100**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007100.zip) | Nokia, Nokia Shanghai Bell | **Proposal1: Do not introduce additional carrier frequency layers due to CSI-RS based RRM measurements.** **Proposal2: The UE shall be capable of monitoring a total of at least 7 NR carriers excluding NR serving carrier(s).** **Proposal3: For CSI-RS based RRM measurement, the carrier/ frequency layer refers to the center frequency of the CSI-RS resources.****Proposal4: There could be one or multiple MOs per frequency layer when CSI-RS based RRM measurement is configured.** **Proposal5: When *associatedSSB* is configured, the UE is supposed to monitor not only the frequency layer of the CSI-RS resource, but also the frequency layer of the *associatedSSB* which is indicated via *ssbFrequency.*** **Proposal6: If the CSI-RS resources with different center frequencies (i.e. layers) are associated with the same *ssbFrequency*, the layer corresponding to the *ssbFrequency* shall be counted only once to the total number of effective carrier frequency layers.** **Proposal7: For intra-frequency measurements, the number of cells the UE is capable of monitoring should be the same as the number defined for SSB-based measurements i.e. 8 identified cells for FR1 and 6 identified cells for FR2, for each intra-frequency layer. In these cells, the UE may be configured for SSB-based and/or CSI-RS based measurements.****Proposal8: The UE shall be capable of measuring** * **For FR1, at least 14 CSI-RS resources for each intra-frequency layer, if no SSB-based measurement or *associatedSSB* is configured on this layer.**
* **For FR2, at least 24 CSI-RS resources for the single serving carrier and 2 CSI-RS resources for other carriers on the same band, if no SSB-based measurement or *associatedSSB* is configured on this layer.**
* **Otherwise, the capability is shared between SSBs and CSI-RS resources.**

**Proposal9: No additional measurement capability is required in a slot per MO.**  |
| [**R4-2007352**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007352.zip) | OPPO | **Proposal 1: Measurement capabilities per MO or per layer are the same.****Proposal 2: Support option 1 that UE shall be able to measure at least 7 effective** **NR frequency layers in total excluding NR serving carrier(s), including SSB frequency layers and CSI-RS frequency layers.****Proposal 3: Considering the different buffer and processing for RRM, MO(s) configured for SSB and/or CS-RS mobility measurement should be taken as different NR frequency layers.****Proposal 4: Support shared capability on number of cells for CSI-RS&SSB:*** + **Number of monitored cells is determined by the UE capability based on SSB based measurements.**
	+ **For FR1, at least 8 and 4 identified cells for intra-f and inter-f measurement respectively.**
	+ **For FR2, at least 6 and 4 identified cells for intra-f and inter-f measurement respectively**

**Proposal 5: Support option 3, and requirements defined the same requirements as those for SSB** * + **If network configures more CSI-RS resources in an MO than the UE measurement capability, the UE behaviour is undefined.**
	+ **For FR1, 14 and 7 CSI-RS resources for intra-f and inter-f measurement respectively.**
	+ **For FR2, 24 and 10 CSI-RS resources for intra-f and inter-f measurement respectively and at least 1 CSI-RS resources per identified cell.**

**Proposal 6: For intra-frequency measurements on FR2, the UE shall also be capable of at least 2 SSBs and 2 CSI-RS resources on serving cell for each of the other serving carrier(s) in the same band.** |
| [**R4-2007650**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007650.zip) | ZTE | ***Proposal 1. UE shall be able to measure at least [7] CSI-RS frequency layers if there is no SSB based measurement is configured.*** ***Proposal 2. The total number of NR frequency layers UE shall be able to monitoring remains unchanged.*** ***Proposal 3. No need to further discuss per MO or per frequency layer.*** ***Proposal 4. Separated UE capability of number of cells and number of CSI-RS resources that the UE shall be capable of performing CSI-RS based measurement for L3 mobility should be specified.******Proposal 5. The same number of cells as for SSB based measurement is used for CSI-RS based measurement.******Proposal 6. The number of CSI-RS resources shall be monitored by UE is specified as in option 2.******Proposal 7. Not to define UE capability to indicate maximum CSI-RS resources in a slot per MO.******Proposal 8. Further study impact of UE capability*** *maxNumberCSI-RS-RRM-RS-SINR* ***to number of beams UE shall be capable of monitoring.*** |
| [**R4-2007864**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007864.zip) | Huawei, HiSilicon | **Proposal 1: CSI-RS measurement capability requirements are defined on per MO basis, and one CSI-RS frequency layer is identical to one MO with CSI-RS.****Proposal 2: Define separate capabilities for SSB measurement and CSI-RS measurement.****Proposal 3: The number of CSI-RS frequency layers is the number of MOs with CSI-RS.****Proposal 4: The number of SSB frequency layers is the total number of MOs with*** **SSB configured as mobility RS (no matter if CSI-RS is configured as mobility RS)**
* **SSB not configured as mobility RS but CSI-RS configured as mobility RS with associated SSB**

**Proposal 5: If SSB related parameters are same in multiple MOs, the multiple MOs can be counted as one SSB layer in capability.** **Proposal 6: The capability in number of frequency layers are defined as** * **SSB intra-frequency layer: 1 per serving cell**
* **CSI-RS intra-frequency layer: 1 per serving cell**
* **SSB inter-frequency layers: 7**
* **CSI-RS inter-frequency layers: 7**
* **Total inter-frequency layers including SSB and CSI-RS: 7**
* **Total inter-frequency and inter-RAT layers: 13**

**Proposal 7: Re-use the SSB requirements for CSI-RS on number of cells UE shall monitor per frequency layer. UE measures the same set of cells for CSI-RS and its associated SSB.****Proposal 8: UE shall monitor at least 32/24 CSI-RS resources for each intra/inter-frequency CSI-RS layer.****Proposal 9: For an FR2 band, UE measures CSI-RS from neighbour cells on one single intra-frequency layer.****Proposal 10: The total number of CSI resources that UE can monitor per slot is indicated by existing capability maxNumberCSI-RS-RRM-RS-SINR.** **Proposal 11:** CSI-RS requirements apply provided that CSI-RS resources in any two consecutive slots are separated by at least 7 symbols.**Proposal 12: RAN4 to discuss the requirements when number of configured CSI-RS resources per slot exceeds the indicated UE capability.*** **Option 1: measurement period is extended**
* **Option 2: other**
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| [**R4-2007867**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007867.zip) | Huawei, HiSilicon | **Proposal 1: Introduce the concept of CMTC in Rel-16, and UE is only required to measure CSI-RS resources within the CMTC window.****Proposal 2: 1 CMTC periodicity can be configured per CSI-RS frequency layer, and the candidate values are {10, 20, 40}ms.****Proposal 3: 1 CMTC duration can be configured per CSI-RS frequency layer, and the candidate values are {1, 2, 3, 4, 5}ms.****Proposal 4: RAN4 does not define restrictions on number of CSI-RS resources periodicities per MO.** |
| [**R4-2008237**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2008237.zip) | Qualcomm CDMA Technologies | **Proposal1: CSI-RS measurement capabilities can be specified per frequency layer. And option 1b is supported.** **Proposal1.1: Regardless of SSB or CSI-RS, total number of NR inter-frequency layers shall be the same. At least 7 effective NR carrier frequency layers shall be measured for UE. Option 1 is supported.****Proposal1.2: Option1 is supported and number of monitored cells is shared for CSI-RS and SSB per frequency layer.** **Proposal1.3: the number of neighbor CSI-RS beams can be equal or more than that of the SSB. As a baseline, following numbers of monitored CSI-RS beams are considered.*** **For FR1, 16 and 8 CSI-RS resources for intra-f and inter-f measurements, respectively.**
* **For FR2, 24 and 16 CSI-RS resources for intra-f and inter-f measurements, respectively.**

**Proposal 1.4: The total number of CSI resources that UE can monitor per slot should come from the UE capability maxNumberCSI-RS-RRM-RS-SINR. And the capability is reserved for RRM purpose.****Proposal 1.5: Given that maxNumberCSI-RS-RRM-RS-SINR shall reflect the UE’s capability in the back2back slot processing, it is not necessary to define new UE capability on the minimum separation between two slots with CSI-RS resources.****Proposal2: Consider the existing mechanisms of time configuration via slotConfig and SMTC for measuring the intra-frequency and inter-frequency CSI-RS resources.** **Proposal2.1: Send a LS to RAN1/2 for clarity on measurement timing configuration for inter-frequency measurements via SMTC based gap or, gaps independent of SMTC.**  |
| [**R4-2006216**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006216.zip) | Apple | Measurement capability* + Measurement capability per MO or per frequency layer

**Proposal 2: Limit one MO per frequency layer so that the measurement per MO or per frequency layer are equivalent.** * + Number of frequency layers to be monitored

**Proposal 3: Existing requirements do not change, i.e. The total number of carrier UE shall be capable of monitoring at least 13 effective carrier frequency layers****Proposal 4: UE shall be able to measure at least 7 NR frequency layers in total, including SSB frequency layers and CSI-RS frequency layers.*** + Number of cells to be monitored

**Proposal 5: Shared capability for CSI-RS&SSB*** + Number of CSI-RS resource/beams to be monitored

**Proposal 6: For FR1, 14 and 7 CSI-RS resources for intra-f and inter-f, respectively. For FR2, 24 and 10 CSI-RS resources for intra- and inter-frequency, respectively and at least 1 CSI-RS resources per cell.*** + UE capability to indicate maximum CSI-RS resources in a slot per MO

**Proposal 7: The total number of CSI resources that UE can monitor per slot should come from the UE capability maxNumberCSI-RS-RRM-RS-SINR.****Proposal 8: Introduce CSI-RS Measurement Timing Configuration (CMTC).*** **All CSI-RS resources for L3 meaurement should be configured within CMTC window**
* **CMTC window duration: considering CSI-RS periodicity is up to 40ms, the CMTC window should be less than 5ms.**
* **Up to 2 CMTC periodicities can be configured per CSI-RS intra-frequency layer**
* **Up to 1 CMTC periodicity can be configured per CSI-RS inter-frequency layer**

**Proposal 9: Further restriction on CSI-RS MO configuration for mobility in Rel-16 include*** **A fixed channel bandwidth per MO should be configured**
* **Up to 2 CSI-RS resources periodicities can be configured per intra-frequency MO**
* **Up to 1 CSI-RS resource periodicity can be configured per inter-frequency MO**
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## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: General

*Sub-topic description:*

In last meeting RAN4 has agreed requirements shall be defined when CSI-RS is configured with an associated SSB. No requirements in Rel-16 for the case associated SSB is not configured for CSI-RS.

* Measurement capabilities per MO or per layer
	+ Option 1: per frequency layer
		- Option 1a (CATT, Nokia): a frequency layer is identical to an MO
		- Option 1b (ZTE,): One or multiple MOs can be one frequency layer.
	+ Option 2: per MO
		- A frequency layer is identical to an MO
	+ Option 3: Measurement capabilities per MO or per layer are the same, since single MO is configured per frequency layer,
		- CSI-RS resources in the same MO should have the same center frequency, SCS and CP type.

*Open issues and candidate options before e-meeting:*

#### **Issue 1-1-1: Alignment on Measurement capabilities per MO or per layer**

* Proposals
	+ Option 1: CSI-RS measurement capability requirements are defined on per layer.
		- One or multiple MOs can be corresponding to one frequency layer.
	+ Option 2: CSI-RS measurement capability requirements are defined on per MO basis.
		- One CSI-RS frequency layer is identical to one MO with CSI-RS. Different MOs are different frequency layers.
	+ Option 3: No need to further discuss per MO or per frequency layer.
* Recommended WF
	+ Based on the definition of CSI-RS frequency layer, measurement capabilities per MO or per layer are the same. Capability requirement is defined per layer.
		- the frequency layer definition for CSI-RS is as follows:
			* the same SCS and CP type
			* the same centre frequency
			* the same value of CSI-RS bandwidth

#### **Comments on Sub-topic 1-1: General**

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| **Issue 1-1-1: Alignment on Measurement capabilities per MO or per layer** |
| **Company** | **Comments** |
| vivo | If per MO and per layer is the same, that means only one MO is allowed for each frequency layer. If per MO and per layer is not the same, i.e. more than one MO is allowed for each frequency layer, per MO basis is a better choice for us. |
| MTK | Support Option 2.This is the discussion on whether to allow multiple MOs for the same frequency layer. We understand the concern from infra vendors that single MO provides only 92 CSI-RS configurations which may not be sufficient if 32 CSI-RS resources are configured per cell. For an example, to configure all CSI-RS of 7 cells, we need 224 CSI-RS which requires 3 MOs. But we want to check if this is a real consideration in deployment because 224 CSI-RS implies a very high RS overhead as well as significant scheduling restriction (e.g., in FR2) on top of what we already have for SSB. It seems to us to disadvantage of this high overhead would outweigh the benefit of introducing CSI-RS for L3 mobility. |
| CATT | Prefer option 1 |
| Intel | have dependency on the definition of intra-f/inter-f CSI-RS based measurement, as well as the definition of layer. If there are several MOs with the same center-frequency and different BWs, are they in the same layer or different layers? If the layer definition only considers the center frequency, then the multiple MO is one layer, otherwise they belong to different layers. We prefer to define the capabilities per layer as the same as that of SSB. |
| ZTE | Option 1. We have provided views why multiple MOs for a center frequency is needed in email thread part 1. We can further discuss on how to reduce UE complexity when specifying RRM requirements. UE is not required to monitor so many CSI-RS resources, but UE has to found out which CSI-RS resources should be being monitored.It may also be fine not to further discuss the mapping between MO and frequency layer. UE capability is specified by per frequency layer and MO configuration can be further discussed when specifying RRM requirements.  |
| Huawei | Option 2. We do not think the capability requirements should be defined with center frequency. First, it is conflicting with RAN1 definition of frequency layer. Second, it requires UE to merge multiple MOs and creates additional complexity e.g. in configuring the measurement and reporting internally. Last, if we define the number of cells and beams also based on center frequency, UE may not measure cells and beams in each MO which is not desirable from network side.We all want to note that network can still configure multiple MOs per center frequency, if the capability requirements are based on MO, but it just means the number of CSI-RS frequency layers is same as number of CSI-RS MOs. |
| Nokia, Nokia Shanghai Bell | We prefer Option1.It is preferred to define the measurement capability per layer as did for SSB-based measurements. In our understanding, there could be multiple MOs in one layer, so layer and MO are not exactly the same.  |
| Qualcomm | Option1 is supported.According to the tentative agreement on the intra-frequency definition, technically one or more MOs can be mapped to one frequency layer. Allowing multiple MOs per layer reserves the flexibility for enabling per MO measurement configurations in terms of SMTC and/or gap. Another benefit is if there are many resources to be measured per layer, they can be distributed among different MOs. |
| Apple | Option 2. No clear benefit to define multiple MO per frequency layer. In our paper R4-2006216, I don’t think we proposed option 1. I revise our position in the email summary. |
| CMCC | For SSB, the measurement capability is specified based on frequency layer. For CSI-RS, we prefer to follow the same approach as SSB. As for the issue on multiple MOs for one frequency layer, we have two options to move forward:Alt 1: If multiple MOs for one frequency layer is considered in Rel-16, we can consider to introduce a new measurement capability, e.g. the number of MOs per frequency layer.Alt 2: considering the limited timeline, only one MO per frequency layer is considered in Rel-16. |
| OPPO | Prefer option 1 per layer to keep alignment with SSB based measurement. Furthermore, we also support single MO is configured per frequency layer, so that measurement capabilities per MO or per layer are the same. |
| Docomo | Prefer Option 2. To avoid complexity of network configuration, frequency layer should be same as MO. |

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|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**No* *Candidate options:**Option 1: 6 companies**Option 2: 4 companies**Recommendations for 2nd round:*Continue discussion and conclude in this meeting.* Option 1: CSI-RS measurement capability requirements are defined on per layer.
	+ One or multiple MOs can be corresponding to one frequency layer.
* Option 2: CSI-RS measurement capability requirements are defined on per MO basis.
	+ One CSI-RS frequency layer is identical to one MO with CSI-RS. Different MOs are different frequency layers.
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### Sub-topic 1-2: number of frequency layers to be monitored

*Sub-topic description*

* Agreement: The total number of carrier UE shall be capable of monitoring at least 13 effective carrier frequency layers
* CSI-RS based NR inter-frequency layers
	+ Option 1 (MediaTek, OPPO, Qualcomm, CATT, Apple, Huawei):
		- UE shall be able to measure at least 7 NR frequency layers in total, including SSB frequency layers and CSI-RS frequency layers.
	+ Option 2 (CMCC):
		- UE shall be able to measure at least [3] CSI-RS frequency layers.
		- UE shall be able to measure at least 8 NR frequency layers in total, including SSB frequency layers and CSI-RS frequency layers.
	+ Option 3 (ZTE):
		- UE shall be able to measure at least [7] CSI-RS frequency layers

*Open issues and candidate options before e-meeting:*

#### **Issue 1-2-1: number of frequency layers to be monitored**

* Proposals
	+ UE shall be able to measure at least [X1] CSI-RS inter-frequency layers if there is no SSB based measurement is configured. At least [X2] NR inter-frequency layers in total including CSI-RS and SSB frequency layers
		- Option 1: X1=X2= 7
		- Option 1a: X1= 0, X2=7 (MediaTek)
		- Option 2: X1=X2= 8 (CMCC, CATT)
* Recommended WF
	+ UE shall be able to measure at least [X1] CSI-RS inter-frequency layers if there is no SSB based measurement is configured. At least [X2] NR inter-frequency layers in total including CSI-RS and SSB frequency layers.
		- FFS on X1 and X2
	+ In summary, number of frequency layers to be monitored
		- SSB intra-frequency layer: 1 per serving cell
		- CSI-RS intra-frequency layer: 1 per serving cell
		- SSB inter-frequency layers: 7
		- CSI-RS inter-frequency layers: 7
		- Total inter-frequency layers including SSB and CSI-RS: 7
		- Total inter-frequency and inter-RAT layers: 13

#### **Issue 1-2-2: SSB frequency layers to be monitored**

* Proposals
	+ Option 1(Huawei):
		- The number of SSB frequency layers is the total number of MOs with
			* SSB configured as mobility RS (no matter if CSI-RS is configured as mobility RS)
			* SSB not configured as mobility RS but CSI-RS configured as mobility RS with associated SSB
		- If SSB related parameters are same in multiple MOs, the multiple MOs can be counted as one SSB layer in capability.
	+ Option 2(Nokia):
		- When associatedSSB is configured, the UE is supposed to monitor not only the frequency layer of the CSI-RS resource, but also the frequency layer of the associatedSSB which is indicated via ssbFrequency.
		- If the CSI-RS resources with different center frequencies (i.e. layers) are associated with the same ssbFrequency, the layer corresponding to the ssbFrequency shall be counted only once to the total number of effective carrier frequency layers.
* Recommended WF
	+ FFS

#### **Comments on Sub-topic 1-2: number of frequency layers to be monitored**

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| **Issue 1-2-1: number of frequency layers to be monitored** |
| **Company** | **Comments** |
| vivo | We support option 1 and fine with the recommended WF.Moreover, we suggest that if both “ssb-ConfigMobility” and “ssb-ConfigMobility” are configured in the same inter-frequncy MO, SSB-based measurement and CSI-RS based measurement are treated as two separate layers. |
| MTK | Option ~~2~~1aFirstly, we need to clarify whether RAN4 allows a MO with only CSI-RS configurations without SSB configuration. In our view, this is infeasible for CSI-RS with associated SSB. UE has to detect the SSB first before performing measurement on CSI-RS. Without SSB-related information, UE cannot start to detect the SSB and therefore cannot perform CSI-RS measurement. So X1 should be 0. In other words, we should empathize in the spec that the layers that UE performs CSI-RS based measurements should only be a sub set of layers that UE performs SSB-based measurements.Regarding X2, 7 is OK to us.**Further comments:** We corrected on typo in our previous comment. We support Option 1a, rather than Option 2. |
| CATT | As mentioned by vivo, “ssb-ConfigMobility” and “ssb-ConfigMobility” are configured in the same inter-frequncy MO, SSB-based measurement and CSI-RS based measurement are treated as two separate layers. Thus, additional frequency layer to be monitored is needed, we support option 2.  |
| ZTE | SSB based measurement and CSI-RS based measurement are independent measurements, even if they are configured in one MO. That’s also why we commented for previous issue that we may not need to discuss mapping between MO and frequency layer.We support Option 2. |
| Huawei | Option 1a. We agree with MTK that since RAN4 only defined requirements for CSI-RS with associated SSB, there should be at least one SSB frequency layers, so we do not need to discuss X1.For X2, we prefer to keep it as 7 to minimize the impact to UE implementation due to introduction of CSI-RS measurement. In addition, we agree with vivo, CATT and ZTE that SSB and CSI-RS are independent measurements, so we should define separate capability requirements for number of SSB layers and CSI-RS layers. CSI-RS are measured with separate computation and memory resources from SSB, and all the efforts for measurement e.g. sampling, buffering, processing, filtering and results saving need to be taken separately for CSI-RS. |
| Nokia, Nokia Shanghai Bell | We agree with X2=7, i.e. to use existing capability but the layers include both CSI-RS and SSB frequency layers. But for X1, as the UE need detect associatedSSB before measuring CSI-RS, it is supposed to monitor at least 1 SSB layer in addition to CSI-RS layers. In this sense, X1 could be maximum 6 i.e. smaller than X2. We are open to the value of X1 but it seems cannot equal to X2 if associatedSSB is configured. In general we are fine with the recommended WF except CSI-RS inter-frequency layers: 7. |
| Qualcomm | Option1a is agreeable for X1 and X2 for the case when no associated SSB is configured.With associated SSBs are configured, the recommended WF is supported. |
| Apple | Option 1a makes sense, since we won’t specify the requirement without associated SSB. |
| CMCC | Firstly, we would like to clarify that we agree that only CSI-RS with associated SSB is considered in Rel-16, which is the agreement in the last meeting. For X1, we would like to have clarification from Moderators. It seems companies have different understanding of X1. According to companies’ comment, it seems that companies think X1 is for the case of CSI-RS measurement without associated SSB. However, we have different understanding. There are two kinds of MO: MO with SSB as mobility resource, MO with CSI-RS with associated SSB as mobility resource. In my understanding, X1 targets for the case that there are only MOs with CSI-RS with associated SSB as mobility resource.Secondly, with the assumption of only CSI-RS with associated SSB is considered in Rel-16, we would like to clarify why we think the number of carriers need to be updated from 7 to 8. There are two considerations. One consideration is that the associated SSB used for CSI-RS measurement may not be the same with the SSB configured as mobility RS in MO. For example, SSB1 is configured as mobility RS in MO1. SSB2 is the associated SSB used for CSI-RS measurement in MO2. SSB 1 and SSB2 are different frequency layers. In this case, the number of SSB UE need to measure will be increased. The other consideration is that, even configured in the same MO, SSB and CSI-RS will have different center frequency, from measurement point of view, the number of frequency layers UE need to measure will be increased. Taking above into consideration, reuse current requirements, which is 7, is not enough. We also understand UE vendors’ concern on the complexity, our proposal is to increase the number from 7 to 8. Option 2 is preferred. |
| OPPO | Option 1a. X1=0, X2=7.And we agree with the recommended WF* number of frequency layers to be monitored
	+ SSB intra-frequency layer: 1 per serving cell
	+ CSI-RS intra-frequency layer: 1 per serving cell
	+ SSB inter-frequency layers: 7
	+ CSI-RS inter-frequency layers: 7
	+ Total inter-frequency layers including SSB and CSI-RS: 7

Total inter-frequency and inter-RAT layers: 13 |

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| **Issue 1-2-2: SSB frequency layers to be monitored** |
| **Company** | **Comments** |
| vivo | We support option 1 and see it is also compatible with option 2. |
| MTK | For Option 1, we have concern on the 3rd condition of Option 1. SSB should be also configured in the same MO so that UE can detect SSB first before measuring CSI-RS. For the other conditions, we are fine.For Option 2, we are OK with the 1st bullet, while the 2nd bullet is pending on the conclusion of Issue 1-1.**Response to Huawei**: It seems in Huawei’s view the definition of ‘SSB configured as mobility RS’ depends on whether ssb-ConfigMobility is configured or not. But in our view the information in ssb-ConfigMobility are {ssb-ToMeasure, deriveSSB-IndexFromCell, ss-RSSI-Measurement} which are not essential for SSB measurement. Instead, other information like {ssbFrequency , ssbSubcarrierSpacing , smtc1} are more essential in our understanding. Therefore, our previous comments were based on the case if the later set of parameters are not configured. |
| ZTE | We don’t think associated SSB should be a frequency layer to be monitored. The SSB measurement are only configured by *ssbFrequency*.  |
| Huawei | Option 1. We also think option 1 and option 2 are quite similar.To MTK, the third condition in option 1 addresses the case where SSB and CSI-RS are configured in the same MO, but ssb-ConfigMobility is not configured, so it seems not the case you are concerned with (where SSB is not configured in the same MO).To ZTE, if we understand correctly, *ssbFrequency* is also used the associated SSB. UE also needs to measure on the frequency layer of the associated SSB, otherwise it cannot measure CSI-RS in the same MO. |
| Nokia, Nokia Shanghai Bell | We also think Option1 and Option2 are very similar expect per MO or per layer. To be more clear, we can reword our proposals in the way below: The number of SSB frequency layers is the total number of “carrier frequencies” including* Ssbfrequency when ssb-ConfigMobility is configured
* Ssbfrequency when CSI-RS-ResourceConfigmobility is configured with associatedSSB
* the ssbfrequency is counted only once if the ssbfrequency in above bullets are the same, or ssbfrequency in multiple MOs are the same.
 |
| Qualcomm | Since in Issue 1-1-1, we support multiple MOs can be mapped to one layer, option 1 is not agreeable to us. Number of MOs is not equivalent to the number of SSB frequency layers in our view.Option 2 unifies the frequency layer of CSI and the frequency layer of SSB as long as the CSI resource is associated to a SSB regardless of whether or not their center frequencies being the same. Eventually, number of SSB frequency layers shall determine the envelope of total number of effective carrier frequency layers. Now if a CSI resource doesnot have associated SSB configured, we believe no requirements should be defined. Option2 is thus agreeable to us. |
| Apple | We are not sure if option 1 and 2 are addressing the same issues. Here are what we agree with in both option 1 and 2* The number of SSB frequency layers is the total number of MOs with
* When associatedSSB is configured, the UE is supposed to monitor not only the frequency layer of the CSI-RS resource, but also the frequency layer of the associatedSSB which is indicated via ssbFrequency.
* If the CSI-RS resources with different center frequencies (i.e. layers) are associated with the same ssbFrequency, the layer corresponding to the ssbFrequency shall be counted only once to the total number of effective carrier frequency layers.
 |
| OPPO | Agree with option 1 and 2 in principle. If per layer was agreed in Issue 1-1-1, we can also support the proposals by Nokia:The number of SSB frequency layers is the total number of “carrier frequencies” including* Ssbfrequency when ssb-ConfigMobility is configured
* Ssbfrequency when CSI-RS-ResourceConfigmobility is configured with associatedSSB
* the ssbfrequency is counted only once if the ssbfrequency in above bullets are the same, or ssbfrequency in multiple MOs are the same.
 |

### Sub-topic 1-3: number of cells to be monitored

*Sub-topic description*

* Option 1 (MediaTek, OPPO, Qualcomm, Nokia): Shared capability for CSI-RS&SSB
	+ Number of monitored cells is determined by the UE capability based on SSB based measurements.
* Option 2 (Huawei, CATT, CMCC):  Separated capability for CSI-RS
	+ Option 2a (Huawei):
		- Re-use the SSB requirements for CSI-RS on number of cells UE shall monitor per layer.
	+ Option 2b (CMCC):
		- For each intra-frequency layer, UE is capable of measuring [8] CSI-RS cell;
		- For each inter-frequency layer, UE is capable of measuring [4] CSI-RS cell.
* Option 3 (ZTE): Capabilities for CSI-RS only and CSI-RS&SSB
	+ UE shall be capable of performing CSI-RS based measurements for at least [8] identified cells in FR1 for intra frequency measurement and at least [4] identified cells in FR1 for inter frequency measurement, at least [6] identified cells in FR2 for intra frequency measurement and at least [4] identified cells in FR2 for inter frequency measurement.
	+ UE shall be capable of performing SSB and CSI-RS based measurements for at least [12] identified cells in FR1 for intra frequency measurement and at least [6] identified cells in FR1 for inter frequency measurement.
	+ UE shall be capable of performing CSI-RS based measurements for at least [9] identified cells in FR2 for intra frequency measurement and at least [6] identified cells in FR2 for inter frequency measurement.

*Open issues and candidate options before e-meeting:*

#### **Issue 1-3-1: number of cells to be monitored per layer**

* Proposals
	+ Option 1: Support shared capability for CSI-RS&SSB((MediaTek, OPPO, Qualcomm, Nokia, Apple)
		- Number of monitored cells is determined by the UE capability based on SSB based measurements.
			* For each intra-frequency layer, UE is capable of measuring [8] identified cell for FR1 and [6] identified cells for FR2.
			* For each inter-frequency layer, UE is capable of measuring [4] identified cell for both FR1 and FR2.
	+ Option 2: Separated capability for CSI-RS and SSB (CMCC, ZTE, CATT, Huawei )
		- For each intra-frequency layer, UE is capable of measuring [8] CSI-RS cell for FR1 and [6] CSI-RS cells for FR2.
		- For each inter-frequency layer, UE is capable of measuring [4] CSI-RS cell for both FR1 and FR2
* Recommended WF
	+ Decide whether to define shared capability or separated capability for monitored cells for CSI-RS and SSB based measurement
	+ For either option 1 or 2, the majority view on the number of identified cells is reusing the values for SSB.
		- Each intra-frequency layer：8 for FR1, 6 for FR2
		- Each inter-frequency layer：4 for FR1, 4 for FR2

#### **Comments on Sub-topic 1-3: number of cells to be monitored**

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| **Issue 1-3-1: number of cells to be monitored per layer** |
| **Company** | **Comments** |
| vivo | For intra-frequency layer, if frequency layer definition follows WF in 1-1-1, shared capability is a better choice for CSI-RS based RRM.For inter-frequency layer, in one MO where both “ssb-ConfigMobility” and “csi-rs-ResourceConfigMobility” are configured, SSB and CSI-RS should be treated as 2 different frequency layers. If such proposal can be adopted, we support separate capability on these layers. If they are not treated as different frequency layer, maybe shared capability is better for this case.If only one of “ssb-ConfigMobility” and “csi-rs-ResourceConfigMobility” is configured, we support separate capability on each MO. |
| MTK | Support Option 1 with the additional note that the cells that UE monitors based on CSI-RS is only a sub set of cells that UE monitors based on SSB. **Response to CATT, ZTE and Huawei**: please consider that RAN4 had made an agreement to specify requirements only for CSI-RS with associated SSB. UE is not required to monitor that CSI-RS resource if the UE cannot detect the SS/PBCH block indicated by this associatedSSB and cellId. In that case, specify a separate and independent requirements for # of cells for CSI-RS does not make sense, because UE is not going to measure the CSI-RS if its associated SSB is not detectable.

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| ***associatedSSB***If this field is present, the UE may base the timing of the CSI-RS resource indicated in *CSI-RS-Resource-Mobility* on the timing of the cell indicated by the *cellId* in the *CSI-RS-CellMobility*. In this case, the UE is not required to monitor that CSI-RS resource if the UE cannot detect the SS/PBCH block indicated by this *associatedSSB* and *cellId*. … *text omitted* |

 |
| CATT | Option 2. Regarding the number of cells, we support to define separate capability for CSI-RS based measurement. Since the center frequency of “ssb-ConfigMobility” and “ssb-ConfigMobility” are different, UE may not be able to measurement SSB and CSI-RS simultaneously. |
| ZTE | Option 2.We disagree with MTK’s view that cells that UE monitors based on CSI-RS is only a sub set of cells that UE monitors based on SSB. As we commented earlier, SSB based measurement and CSI-RS based measurement are independent. It is not typical use case that a cell is monitored with both SSB measurement and CSI-RS measurement. Usually it is either SSB based measurement or CSI-RS based measurement. |
| Huawei | Option 2.We think separate capability requirements should be defined for SSB and CSI-RS measurement because they are independent measurement. In particular, for number of cells, we agree UE measures the same set of cells for CSI-RS and its associated SSB, but it does not mean the capability is shared between SSB and CSI-RS. |
| Nokia, Nokia Shanghai Bell | We prefer Option1.As the CSI-RS based measurement is conditioned on the associatedSSB detection in the same cell, the measurement on CSI-RS does not add additional number of cells over the number for SSB-based measurement. So, the same capability can be kept and shared between CSI-RS and SSB based measurements.  |
| Qualcomm | Option1 is supported.CSI-RS cell is not a clear notion to us. CSI-RS alone cannot identify a cell. As a so called CSI-RS cell refers to the cell that is identified via the associated and detected SSB anyhow, separated capability is not necessary. |
| Apple | Opiton 1.I revised email summary to reflect our proposal 5 in R4-2006216. |
| CMCC | Option 2We do not understand why shared capability of number of cells for CSI-RS & SSB can be considered. In our view, no matter intra-frequency layer or not, the center frequency of SSB and center frequency of CSI-RS will be different, from measurement point of view, SSB and CSI-RS are measured separately. |
| OPPO | Support option 1. Similar to issue 1-2-1, the total number of cells in total of SSB and CSI-RS based measurement can be the same as those for Rel-15 SSB based measurement. If the same MO is configured with both “ssb-ConfigMobility” and “csi-rs-ResourceConfigMobility, in our view it counts as one frequency (as is identical to one MO). And this also depends on the conclusion of issue 1-1-1. |

### Sub-topic 1-4: number of CSI-RS resource/beams to be monitored per layer/MO

*Sub-topic description*

* Option 1(CATT, Huawei): UE shall monitor at least 32 CSI-RS resources per frequency layer
* Option 2(ZTE): Define different UE capability for different scenarios, and number of CSI-RS resources shall be monitored by UE,
	+ [24] CSI-RS resources for intra frequency measurements in FR1
	+ [48] CSI-RS resources for intra frequency measurements in FR2,
	+ [16] CSI-RS resources for inter frequency measurements in FR1,
	+ [24] CSI-RS resources for inter frequency measurements in FR2.
* Option 3 (MTK,OPPO, Apple): Requirements defined the same requirements as those for SSB
	+ If network configures more CSI-RS resources in an MO than the UE measurement capability, the UE behavior is undefined.
	+ For FR1, 14 and 7 CSI-RS resources for intra-f and inter-f, respectively.
	+ For FR2, 24 and 10 CSI-RS resources for intra- and inter-frequency, respectively and at least 1 CSI-RS resources per cell.
* Option 4 (CMCC, Huawei)：
	+ For each intra-frequency layer, the number of CSI-RS resource is proposed to be [32].
	+ For each inter-frequency layer, the number of CSI-RS resource is proposed to be [24].
* Do not preclude other options (Qualcomm)

*Open issues and candidate options before e-meeting:*

#### **Issue 1-4-1: number of CSI-RS resource/beams to be monitored for each intra-f and inter-f layer**

* Proposals
	+ CSI-RS resources for each intra frequency layer in FR1
		- Option 1: 14 (MTK, OPPO, Apple, Nokia)
		- Option 2: 16 (Qualcomm)
		- Option 3: 24 (ZTE, CATT)
		- Option 4: 32 (CMCC, Huawei)
	+ CSI-RS resources for each intra frequency layer in FR2
		- Option 1: 24 (MTK, OPPO, Apple, Nokia, Huawei, Qualcomm, CATT)
		- Option 2: 42 (CMCC)
		- Option 3: 48 (ZTE)
		- Option 4: 32 (Huawei)
	+ CSI-RS resources for each inter frequency layer in FR1
		- Option 1: 7 (MTK, OPPO, Apple)
		- Option 2: 16 (ZTE, Qualcomm)
		- Option 3: 24 (CMCC, CATT, Huawei)
	+ CSI-RS resources for each inter frequency layer in FR2
		- Option 1: 10 (MTK, OPPO, Apple)
		- Option 2: 16 (Qualcomm)
		- Option 3: 24 (ZTE, Huawei, CATT)
		- Option 4: 34 (CMCC)
* Recommended WF
* Define number of CSI-RS resource/beams to be monitored for each intra-f and inter-f layer based on majority views, leaving the values in [] as TBD.
	+ - [14] CSI-RS resources for intra frequency measurements in FR1
		- [24] CSI-RS resources for intra frequency measurements in FR2,
		- [7] CSI-RS resources for inter frequency measurements in FR1,
		- [10/ 24] CSI-RS resources for inter frequency measurements in FR2.
* Discuss whether and how the capability can be shared between SSBs and CSI-RS resources.

#### **Issue 1-4-2: CSI-RS resource/beams to be monitored for FR2 intra-f layer**

* Proposals
	+ Option 1: For an FR2 band, UE measures CSI-RS from neighbour cells on one single intra-frequency layer. (Huawei)
	+ Option 2: For intra-frequency measurements on FR2, the UE shall also be capable of at least 2 SSBs and 2 CSI-RS resources on serving cell for each of the other serving carrier(s) in the same band.(Nokia, OPPO)
* Recommended WF
	+ Option 2

#### **Comments on Sub-topic 1-4: number of CSI-RS resource/beams to be monitored per layer/MO**

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| **Issue 1-4-1: number of CSI-RS resource/beams to be monitored for each intra-f and inter-f layer** |
| **Company** | **Comments** |
| vivo | We suggest to differentiate beams for associated SSB and beams for CSI-RS. Since beams for CSI-RS should be finer beams, we are fine to support more beams of CSI-RS, if the beams of associated SSB is limited to be the same as or less than SSB-based requirement, and measurement accuracy is derived based on the timing of associated SSB for inter frequency. |
| MTK | Support Option 1. As we explained several times in previous meetings, finer beamwidth does not guarantee better robustness in mobility performance. We wonder how more CSI-RS beams from gNB is going to maintain the same mobility robustness as SSB-based measurement. More and finer CSI-RS beams means the coverage of each CSI-RS beam becomes narrower than a SSB beam. This is going to increase the chance of handover failure because the best CSI-RS beam reported by UE could be highly likely not a suitable beam to that UE after handover.  |
| CATT | We agree with the recommended WF. |
| ZTE | It’s hard to choose options given the structure of the issue. Our compromised proposal is for per frequency layer.[24] CSI-RS resources for intra frequency measurements in FR1[32] CSI-RS resources for intra frequency measurements in FR2,[16] CSI-RS resources for inter frequency measurements in FR1,[24] CSI-RS resources for inter frequency measurements in FR2The above proposal is for CSI-RS capability only.The CSI-RS based mobility is mainly used to avoid consistent interference when measuring as SSB does. The finer beams doesn’t mean mismatch of coverage compared to SSB. There are ways to ensure the same coverage. The fine beams can get more accurate results to help decision on mobility. |
| Huawei | We think it is reasonable to support a higher number of beams per layer for CSI-RS than for SSB. ZTE proposal above looks reasonable to us. |
| Nokia, Nokia Shanghai Bell | We think it is simpler to start from Option1, but we are fine with higher number of CSI-RS resources if it is acceptable to UE. Reusing the existing number could be starting point for CSI-RS based measurement, and the capability is shared between CSI-RS and SSB based measurement. In Option 1, it is also noted 24 for intra-frequency measurement in FR2 applies to the first serving carrier in one band. For the other carriers on the same band, 2 is applied.  |
| Qualcomm | Although issue 1-3-1 projects the max number of cells to be monitored, we may need to look at realistic numbers of intra-frequency and inter-frequency neighbor SSBs in the field deployment. Then a factor of [X] CSI-RS beams per SSB beam could be assumed to derive the number of CSI-RS resources per layer for providing a similar coverage. We would like to hear companies’ views on the practical deployment.Need more discussions. |
| Apple | WF is good for us except the CSI-RS resources for inter frequency measurements in FR2. |
| CMCC | We disagree with the recommended WF, especially for FR1 intra frequency measurement, larger number need to be considered. We prefer 32 for intra frequency layer in FR1. |
| OPPO | We agree with the recommended WF. As compromise, the values of option 1 can be as baseline in the square brackets to move forward.* [14] CSI-RS resources for intra frequency measurements in FR1
* [24] CSI-RS resources for intra frequency measurements in FR2,
* [7] CSI-RS resources for inter frequency measurements in FR1,
* [10] CSI-RS resources for inter frequency measurements in FR2.
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| **Issue 1-4-2: number of CSI-RS resource/beams to be monitored for FR2 intra-f layer** |
| **Company** | **Comments** |
| vivo | On option 1, we support the view.On option 2, we are fine with the proposal. |
| MTK | We are OK to both Option 1 and Option 2. They can be combined into ~~2~~1 proposal.**Further comment**: a correct to our previous comments 2 🡪 1**Response to ZTE and Qualcomm**: If we follow the same approach as we did for SSB. 1-4-1 and 1-4-2 can be decoupled. In SSB case, only one carrier out of a FR2 band requires UE to perform neighboring cell search. And RAN4 specified a more complete requirement in terms of # of cells and beams for this particular carrier. As for the other carrier, only serving cell measurement is required, the # of beams to be monitored is also smaller to reduce UE complexity. Therefore, we can decouple 1-4-1 and 1-4-2. |
| CATT | Agree with MTK |
| ZTE | What’s the relation to Issue 1-4-1? |
| Huawei | Same comment as MTK. |
| Nokia, Nokia Shanghai Bell | We prefer Option2.For intra-frequency measurement in FR2, we can adopt the principle of SSB-based measurement for CSI-RS based measurement. According to 38.133, 24 SSBs for intra-frequency measurement in FR2 applies to the first serving carrier in one band. For the other carriers on the same band, 2 is applied. About Option1, what does it mean exactly? Does the UE only measure single intra-f layer for FR2?  |
| Qualcomm | Agree with ZTE. Can we please clarify the issue v.s. previous issue 1-4-1? |
| Apple | Current wording is not very clear. Some revisions are suggested* Per FR2 band, intra-f CSI-RS measurement for neighbour cells is only required for PCell/PSCell or one of SCell if there is no PCell/PSCell on that band
* UE shall also be capable of at least 2 SSBs and 2 CSI-RS resources on serving cell per CC in the same band.
 |
| OPPO | Response to ZTE, Nokia and QC: this issue was raised aiming to discussing the additional requirements for UE capability of FR2 intra-frequency measurement. The similar requirements are defined for SSB based measurement. And I also add the companies who proposed the corresponding option(s). Maybe further clarification could be provided.We support option 2 and also agree with vivo, and MTK on combination of the two options since the two options are not contradictory. The revisions by Apple are ok for us. |

### Sub-topic 1-5: Buffering and processing capability

#### **Issue 1-5-1: UE capability to indicate maximum number of CSI-RS resources in a slot per MO**

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| **WF on UE capability to indicate maximum CSI-RS resources in a slot per MO*** Option 1(Huawei, MTK, OPPO): Introduce UE capability to indicate the maximum number of CSI-RS resources per MO in a slot.
* Option 2 (ZTE): Not to define UE capability to indicate maximum CSI-RS resources in a slot per MO.
* Option 3(Qualcomm, Apple, Huawei): The total number of CSI resources that UE can monitor per slot should come from the UE capability maxNumberCSI-RS-RRM-RS-SINR.
	+ FFS how to split up
 |

* Proposals
	+ Option 1 (MTK): Since only requirements with associated SSB will be defined, the UE processing capability in a slot per MO should be revised to consider only the CSI-RS resources to be measured with detectable associated SSB.
	+ Option 2 (Huawei, Qualcomm, Apple): The total number of CSI resources that UE can monitor per slot is indicated by existing capability *maxNumberCSI-RS-RRM-RS-SINR.*
	+ Option 3 (ZTE, Nokia): Not to define UE capability to indicate maximum CSI-RS resources in a slot per MO.
	+ Recommended WF
	+ Discuss and decide whether to define UE capability.
		- If option 3 is agreed, no more discussion.
		- If option 1 or 2 is agreed, UE capability is introduced. Discuss how to reuse or revise the existing capability.

#### **Issue 1-5-2:** the requirements when number of configured CSI-RS resources per slot exceeds the indicated UE capability.

* + Option 1: measurement period is extended
	+ Option 2: other
	+ Recommended WF
	+ FFS.

#### **Issue 1-5-3: whether to introduce minimum separation between two slots with CSI-RS resources**

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| * Option 1: Introduce UE capability on the minimum separation between two slots with CSI-RS resources.
* Option 2: Not to introduce UE capability on the minimum separation between two slots with CSI-RS resources.
 |

* Proposals
	+ Option 1: Yes
		- Introduce UE capability on the minimum separation between two slots with CSI-RS resources.
	+ Option2: No
		- Not to define UE capability on the minimum separation between two slots with CSI-RS resources.
	+ Option 3: FFS
		- Pending on the conclusion of time domain limitation of the CSI-RS per MO in another discussion.
* Recommended WF
	+ FFS

#### **Issue 1-5-4: Minimum symbol separation between CSI-RS resources in two consecutive slots**

* Proposals
	+ Option 1: CSI-RS requirements apply provided that CSI-RS resources in any two consecutive slots are separated by at least 7 symbols.
* Recommended WF
	+ If issue 1-5-3 is yes, further discuss the requirement for separation.

#### **Comments on Sub-topic 1-5: Buffering and processing capability**

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| **Issue 1-5-1: UE capability to indicate maximum number of CSI-RS resources in a slot per MO** |
| **Company** | **Comments** |
| vivo | We support option 2. |
| MTK | Option 1 is just an update of the wording based on the agreement to define requirements for associated SSB only.Regarding Option 2, how to interpret this capability in RAN4 needs some further discussion. Note that this capability considers all frequency layers.

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| ***maxNumberCSI-RS-RRM-RS-SINR***Defines the maximum number of CSI-RS resources for RRM and RS-SINR measurement across all measurement frequencies per slot. If UE supports any of *csi-RSRP-AndRSRQ-MeasWithSSB*, *csi-RSRP-AndRSRQ-MeasWithoutSSB*, and *csi-SINR-Meas*, UE shall report this capability. |

However, for inter-frequency measurement, UE is only required to perform measurement on one single frequency layer at a time. For intra-frequency layer, RAN4 may introduce CSSF to address the searcher constraint when performing measurements on multiple layers at the same time. RAN4 should first clarify how to interpret this capability. |
| ZTE | We share MTK’s view that the existing UE capability should be further clarified in RAN4 since it was agreed in RAN1 and we think RAN4 is the more suitable place to decide such UE capability. If necessary clarification from RAN1 is needed.In addition to this existing UE capability it is absolutely not necessary to introduce new UE capability for in slot per MO.  |
| Huawei | Option 2.To MTK, we agree that what matters for UE processing is the number of CSI-RS resources with detectable SSBs, but we can capture this interpretation for the existing capability and there is no need to revise definition. |
| Nokia, Nokia Shanghai Bell | We prefer Option2.It seems the moderator misunderstood our proposal – we proposed no “additional” UE capability is required in our contribution R4-2007100 and it is sufficient to reuse existing *maxNumberCSI-RS-RRM-RS-SINR.* |
| Qualcomm | Option2(*maxNumberCSI-RS-RRM-RS-SINR*) is supported. |
| Apple | Option 2 |
| OPPO | Support Option 2. |

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| **Issue 1-5-2:** the requirements when number of configured CSI-RS resources per slot exceeds the indicated UE |
| **Company** | **Comments** |
| vivo | We prefer no requirement if number of CSI-RS exceeds UE capability. |
| MTK | Same view as vivo. |
| ZTE | RAN4 requirements are specified for defined UE capability only. If exceeding UE capability it is up to UE implementation on how to handle. |
| Huawei | We are also fine to leave no requirement if the number of configured CSI-RS resources per slot exceeds the indicated UE capability. |
| Nokia, Nokia Shanghai Bell | If the UE indicates the capability, the network is assumed to configure proper number of CSI-RS resources for the measurement. Is it a corner case that network does not configure properly?  |
| Qualcomm | If network doesnot configure properly, e.g., more CSI-RS resources than the UE capability (*maxNumberCSI-RS-RRM-RS-SINR.*), we think no requirements shall be defined to be fair. |
| Apple | Agree that no requirement should be specified in this case. |
| OPPO | Agree with vivo, Huawei, Qualcomm and Apple. No requirements for this corner case. |

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| **Issue 1-5-3: whether to introduce minimum separation between two slots with CSI-RS resources** |
| **Company** | **Comments** |
| vivo | We think option 3 reflects current situation. |
| MTK | Support Option 3. If there is a clear time domain limitation of CSI-RS per MO (or per frequency layer), perhaps there is no need to discuss slot separation anymore. |
| ZTE | Agree with MTK there is no need to discuss this. |
| Huawei | Option 2.This is a separate issue from time domain limitation of CSI-RS measurement, because even we have a time window for CSI-RS like SMTC, there may still be a need to have slot separation within the window. But anyway, technically we see no need to have this capability as UE in worst case can be configured to measure in consecutive slot. |
| Qualcomm | We see the concern raised by Huawei after reviewing Issues 1-5-3 and 1-5-4. In the worst case, CSI-RS L3 resources can be configured in back2back slots. In which case, some separation in slots(in issue 1-5-3) or symbols(in issue 1-5-4) could be necessary for certain Ues. As such, we kindly ask the Moderator and companies if it is agreed to combine the two issues under “**whether to introduce minimum separation between two slots with CSI-RS resources**”. For which, we would like to propose by extending the option 1 as below. Thanks for the attention.**Option1a,** Introduce a UE capability on the minimum separation between two consecutive slots with CSI-RS resources in the unit of [n]x125us. (multiples of FR2 slot duration, where n=1,2,4,8,16) |
| Apple | Option 3. It is related to time domain limitation. |
| OPPO | Further discussion is needed. |

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| **Issue 1-5-4: Minimum separation between two slots with CSI-RS resources** |
| **Company** | **Comments** |
| Huawei | The issue is not correctly capturing our Proposal 11 in R4-2007864, so we change it in the summary.Technically, the requirement on UE buffering and processing depends on how CSI-RS is distributed on symbols in consecutive slots. For example, with the same number of CSI-RS resources per slot, case (a) would be more challenging than case (b). Therefore, we propose CSI-RS requirements apply provided that CSI-RS resources in any two consecutive slots are separated by at least 7 symbols. |
| Qualcomm | Please refer to our reply in above issue 1-5-3. |
| Apple | It is suggested FFS on this topic |
| OPPO | Further discussion is needed. |

### Sub-topic 1-6: On CSI-RS resources configurations

In last meeting, RAN4 agreed to introduce restrictions about time-domain scheduling for CSI-RS resources. Whether and how to introduce CMTC are to be discussed in this meeting in WF. The parameters including at least CMTC window length and periodicity should also be further discussed in this meeting.

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| * FFS the maximum number of CSI-RS resources periodicities configured per intra-frequency and inter-frequency MO
* FFS how to introduce CMTC
	+ Option 1:Introduce CSI-RS Measurement Timing Configuration
		- All CSI-RS resources for L3 meaurement should be configured within CMTC window
		- CMTC window duration: considering CSI-RS periodicity is up to [40]ms, the CMTC window should be less than [5] ms.
		- Up to [2] CMTC periodicities can be configured per CSI-RS intra-frequency layer
		- Up to [1] CMTC periodicity can be configured per CSI-RS inter-frequency layer
* FFS whether to introduce CMTC in Rel-16
 |

#### **Issue 1-6-1: Whether to introduce restriction on CSI-RS MO configuration**

* Proposals
	+ Option 1 (Apple):
		- Further restriction on CSI-RS MO configuration for mobility in Rel-16 include
			* A fixed channel bandwidth per MO should be configured
			* Up to 2 CSI-RS resources periodicities can be configured per intra-frequency MO
			* Up to 1 CSI-RS resource periodicity can be configured per inter-frequency MO
	+ Option 2 (Huawei):
		- RAN4 does not define restrictions on number of CSI-RS resources periodicities per MO.
	+ Option 3 (Intel):
		- Considering the flexibility of CSI-RS, more configuration options of CSI-RS than that of SSB can be designed.
	+ Option 4: Up to RAN2.
* Recommended WF
	+ FFS

#### **Issue 1-6-2: How to introduce time-domain restriction on CSI-RS resources configuration**

* Proposals
	+ Option 1: (Apple):
		- Introduce CSI-RS Measurement Timing Configuration (CMTC).
			* All CSI-RS resources for L3 meaurement should be configured within CMTC window
			* CMTC window duration: considering CSI-RS periodicity is up to 40ms, the CMTC window should be less than 5ms.
			* Up to 2 CMTC periodicities can be configured per CSI-RS intra-frequency layer
			* Up to 1 CMTC periodicity can be configured per CSI-RS inter-frequency layer
	+ Option 2 (Huawei):
		- Introduce the concept of CMTC in Rel-16
			* UE is only required to measure CSI-RS resources within the CMTC window.
			* 1 CMTC periodicity can be configured per CSI-RS frequency layer, and the candidate values are {10, 20, 40}ms.
			* 1 CMTC duration can be configured per CSI-RS frequency layer, and the candidate values are {1, 2, 3, 4, 5}ms.
	+ Option 3 (Qualcomm):
		- Consider the existing mechanisms of time configuration via slotConfig and SMTC for measuring the intra-frequency and inter-frequency CSI-RS resources.
		- Send a LS to RAN1/2 for clarity on measurement timing configuration for inter-frequency measurements via SMTC based gap or, gaps independent of SMTC.
	+ Option 4 (Nokia):
		- It is up to RAN2 to discuss whether CSI-RS based measurement window is required or not.
	+ Option 5 (MediaTek)
		- Limit CSI-RS resources to be confined in the SMTC duration of the same MO.
* Recommended WF
	+ Decide whether to introduce CMTC or how to confine in SMTC in Rel-16
		- FFS on parameters (based on Option 1 or Option 2)
	+ If agreed on measurement timing configuration, send LS to RAN1/2 in this meeting

#### **Comments on Sub-topic 1-6: On CSI-RS resources configurations**

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| **Issue 1-6-1: Whether to introduce restriction on CSI-RS MO configuration** |
| **Company** | **Comments** |
| vivo | One periodicity that is equal to the SMTC periodicity would be enough for R16. |
| MTK |

|  |  |
| --- | --- |
| Yes.A time domain limitation is essential to identify the relation to measurement gap, e.g., fully overlapped, partial overlapped or fully non-overlapped. Without this relation clarified, it is very difficult to progress on the CSSF requirements. If there is no time to introduce new signaling, then we suggest to limit CSI-RS in existing SMTC duration.**Response to CATT**: The concern here is not about the same or different measurement engine for SSB and CSI-RS. It is about how to minimize the remaining work in RAN4 as well as to reduce the UE scheduling complexity on determining which measurement gap to be used for which frequency layer. **Response to Nokia and ZTE**: We do not think it is a good approach to allow arbitrary time domain flexibility. If you open up section 9.1.5, you will see the follow sentence about the CSSF framework for SSB, which requires a per-MO relation to gap. Without proper time-domain limitation, how should we specify the corresponding CSSF requirement?

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| 9.1.5.1 Monitoring of multiple layers outside gapsThe carrier-specific scaling factor CSSFoutside\_gap,i for measurement object *i* derived in this chapter is applied to following measurement types:- Intra-frequency measurement with no measurement gap in clause 9.2.5, when none of the SMTC occasions of this intra-frequency measurement object are overlapped by the measurement gap.- Intra-frequency measurement with no measurement gap in clause 9.2.5, when part of the SMTC occasions of this intra-frequency measurement object are overlapped by the measurement gap.UE is expected to conduct the measurement of this measurement object *i* only outside the measurement gaps.…9.1.5.2 Monitoring of multiple layers within gapsThe carrier-specific scaling factor CSSFwithin\_gap,i for measurement object *i* derived in this chapter is applied to following measurement types:- Intra-frequency measurement object with no measurement gap in clause 9.2.5, when all of the SMTC occasions of this intra-frequency measurement object are overlapped by the measurement gap.- Intra-frequency measurement object with measurement gap in clause 9.2.6.- Inter-frequency measurement object in clause 9.3.*- text omitted*UE is expected to conduct the measurement of this measurement object *i* only within the measurement gaps. |

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| CATT | We are fine to restrict CSI-RS resource in time domain. We prefer to introduce the restriction when defining the requirement in RAN4 other than introducing new signaling due to time limit.To MTK, if dedicated searcher is assumed for CSI-RS measurement, it is not necessary to limit CSI-RS resource in existing SMTC duration. |
| Intel | considering the flexibility of CSI-RS, it’s preferred to have some restrictions at least for defining the requirement in RAN4. |
| ZTE | It is not necessary to restrict the periodicity. In Rel-16 we may define requirements for certain configurations. |
| Huawei | We do not see the need to define explicit restrictions on the MO configuration. Instead, it is enough to define the measurement window and that UE is only required to measure CSI-RS resources within the window. |
| Nokia, Nokia Shanghai Bell | In our view, the CSI-RS MO configuration is designed by RAN1/RAN2 and up to network implementation. CSI-RS differs from SSB with narrower beams, more flexible locations. It makes no sense to limit the configuration just to facilitate the requirements definition.  |
| Qualcomm | We agree it is necessary to introduce restrictions on the CSI-RS MO configurations due to the potentially large number of measured resources. Such a restriction may not be directly constraining the periodicities. Instead, RAN4 needs to agree on a recommended approach to confine the CSI-RS measurements within a time window rather than scatter them. The motive is to avoid interruptions on the serving cell. Therefore, option 2 is agreeable to us so network has the flexibility to schedule the CSI-RS resources as needed.  |
| Apple | Yes, it is important to introduce time domain restriction on CSI-RS MO configuration in R16. |
| CMCC | Considering the limited timeline, and according to WID, there is no RAN1/2 TU, we prefer to solve this issue in RAN4. From our point of view, similar view as CATT and ZTE, we can consider to define requirements for some scenario/configuration.  |
| OPPO | We are fine to introduce restrictions on the CSI-RS MO configurations.  |
| Docomo | We have similar view as Huawei, thus we also think there is no need to introduce any restriction on periodicity. |

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| **Issue 1-6-2: How to introduce time-domain estriction on CSI-RS resources configuration** |
| **Company** | **Comments** |
| vivo | We think option 5 is a better way to move forward in R16. For UE performing CSI-RS measurement, UE may need first to obtain timing based on the associated SSB, and it is better to measure CSI-RS right after the timing is obtained.Note that in previous version of 38.215 CSI-RS is already confined in SMTC but got removed in later version. We think such confinement is feasible, although not optimal. Enhancement can be done in later release. |
| MTK | Support Option 5.It may be difficult for RAN4 to agree on a new signaling in this meeting. Also some companies have views that this signaling should be discussed in either RAN1 or RAN2. However, this time domain limitation is very important for RAN4 to reduce the spec workload as well as to progress the discussion on CSSF. Therefore, limiting CSI-RS in SMTC could be considered as a compromise for the time being. |
| CATT | We prefer to introduce the restriction (CSI-RS resources are configured in 5ms window) when defining the requirement in RAN4 other than introducing new signaling due to time limit. If dedicated searcher is assumed for CSI-RS measurement, it is not necessary to limit CSI-RS resource in existing SMTC duration. |
| ZTE | Share CATT’s view. |
| Huawei | We also share similar view as CATT. |
| Nokia, Nokia Shanghai Bell | We understood the CMTC is supposed to be configured by the network, so is more in RAN1/2 scope. Similar as SMTC, it is originated from RAN1/2 not RAN4. Shall we collect the problems with existing CSI-RS configurations and send LS to RAN1/2 asking for the solutions?  |
| Qualcomm | Introduction of CMTC as a new RRC IE seems too late for Rel-16. (while we agree it shall be kept for FFS)For Rel-16, SMTC could be utilized for measurements of CSI-RS. One approach is to schedule a SMTC periodicity of half of the periodicity of SSBs and UE only measures the SMTC window overlapped with the slot instances as determined by the SlotConfig for any CSI-RS resource. Benefit of SMTC is network has the option of configuring CSI-RS measurement window on a per-MO basis. Of course, use case like this shall be guided and confirmed by RAN1/2.CATT’s comment sounds like an approach that solely relies on SlotConfig per CSI-RS resource and network is required for restricting all the resources within a certain time window. We’d suggest introducing a terminology for naming such a window (e.g. “virtual CMTC window” a.k.a VCMTC window).Therefore, options 3 and 5 are supported for Rel-16. |
| Apple | * reusing SMTC of associatedSSB for CSI-RS may not work. Periodicity of CSI-RS is limited by 40ms. However, SMTC periodicity can be much longer than that. When associated SSB periodicity is more than 40ms, it is not clear how to reuse SMTC
* Proposed WF
	+ In R16, Confine CSI-RS resources within SMTC of the associatedSSB and the corresponding periodicity of the SMTC should not be more than 40ms
		- * Up to 2 CSI-RS periodicities can be configured per CSI-RS intra-frequency layer
			* Up to 1 CSI-RS periodicity can be configured per CSI-RS inter-frequency layer
			* The candidate CSI-RS periodicities for L3 measurement are [10,20,40]ms
	+ Introduce CMTC in R17
 |
| CMCC | Similar view as CATT. And we have concern on option 5. Taking FR1 for example, it is typical scenario to transmit the maximum number of SSB, which is 8. Taking this into consideration, we are not OK to limit CSI-RS resources to be confined in the SMTC duration of the same MO.  |
| OPPO | We are also fine to confine CSI-RS resources within SMTC of the associatedSSB, And proposed WF by Apple seems helpful for us to move forward. We can support it. |
| Docomo | Agree with CATT. |

## Companies views’ collection for 1st round

### Open issues

Moderator: please comment directly in the tables under the text of corresponding issues in clause 1.2.

* Sub-topic 1-1: General
* Sub-topic 1-2: number of frequency layers to be monitored
* Sub-topic 1-3: number of cells to be monitored
* Sub-topic 1-4: number of CSI-RS resource/beams to be monitored per layer/MO
* Sub-topic 1-5: Buffering and processing capability
* Sub-topic 1-6: On CSI-RS resources configurations

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

Moderator: How to handle and split CRs will be covered in 1st round summary of email thread [225]. No discussion is expected here.

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| [**R4-2006227**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006227.zip)**(CATT)** | Company A |
| Company B |
|  |
| [**R4-2006766**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006766.zip)**(CMCC)** | Company A |
|  | Company B |
|  |  |
| [**R4-2007353**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007353.zip)**(OPPO)** | Company A |
|  | Company B |
|  |  |
| [**R4-2007354**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007354.zip)**(OPPO)** | Company A |
|  | Company B |
|  |  |
| [**R4-2007355**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007355.zip)**(OPPO)** | Company A |
|  | Company B |
|  |  |
| [**R4-2007865**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007865.zip)**(HW)** | Company A |
|  | Company B |
|  |  |
| [**R4-2007866**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007866.zip)**(HW)** | Company A |
|  | Company B |
|  |  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1-1** | **Issue 1-1-1: Alignment on Measurement capabilities per MO or per layer***Tentative agreements: None* *Candidate options:** *Option 1: 6 companies*
* *Option 2: 4 companies*

*Recommendations for 2nd round:*Continue discussion and conclude in this meeting.* Option 1: CSI-RS measurement capability requirements are defined on per layer.
	+ One or multiple MOs can be corresponding to one frequency layer.
* Option 2: CSI-RS measurement capability requirements are defined on per MO basis.
	+ One CSI-RS frequency layer is identical to one MO with CSI-RS. Different MOs are different frequency layers.
 |
| **Sub-topic#1-2** | **Issue 1-2-1: number of frequency layers to be monitored***Tentative agreements:*UE shall be able to measure at least [X1] CSI-RS inter-frequency layers if there is no SSB based measurement is configured. At least [X2] NR inter-frequency layers in total including CSI-RS and SSB frequency layers.* FFS on X1 and X2

In summary, number of frequency layers to be monitored * SSB intra-frequency layer: 1 per serving cell
* CSI-RS intra-frequency layer: [1] per serving cell
* SSB inter-frequency layers: 7
* CSI-RS inter-frequency layers: [7]
* Total inter-frequency layers including SSB and CSI-RS: [7]
* Total inter-frequency and inter-RAT layers: 13

NOTE: Double confirmation is expected on the values in [] before we remove the square brackets in this meeting*Candidate options:** + Option 1: X1=X2= 7, 1 company
	+ Option 1a: X1= 0, X2=7, 5 companies
	+ Option 1b: X1=6, X2=7, 1 company
	+ Option 2: X1= 8, X2=8, 2 companies

*Recommendations for 2nd round:*Continue discussion. Suggest companies can compromise on option 1a, and double confirmation is expected on the values in [] before we remove the square brackets in this meeting.**Issue 1-2-2: SSB frequency layers to be monitored***Tentative agreements:*Option 1 and 2 in principle are similar expect per MO or per layer, which is still pending on the conclusion of Issue 1-1.*Candidate options:** *Option 1:2 companies*
* *Option 2: 2 companies*

*Recommendations for 2nd round:*Continue discussion based on the updated option 1 and 2.*Option 1:* The number of SSB frequency layers is the total number of MOs with* When associatedSSB is configured, the UE is supposed to monitor not only the frequency layer of the CSI-RS resource, but also the frequency layer of the associatedSSB which is indicated via ssbFrequency.
* If the CSI-RS resources with different center frequencies (i.e. layers) are associated with the same ssbFrequency, the layer corresponding to the ssbFrequency shall be counted only once to the total number of effective carrier frequency layers.

*Option 2:* The number of SSB frequency layers is the total number of “carrier frequencies” including* Ssbfrequency when ssb-ConfigMobility is configured
* Ssbfrequency when CSI-RS-ResourceConfigmobility is configured with associatedSSB
* the ssbfrequency is counted only once if the ssbfrequency in above bullets are the same, or ssbfrequency in multiple MOs are the same.
 |
| **Sub-topic#1-3** | **Issue 1-3-1: number of cells to be monitored per layer***Tentative agreements:* None*Candidate options:** *Option 1: 5 companies*
* *Option 2: 4 companies*

*Recommendations for 2nd round:*Continue discussion and conclude in this meeting. * FFS if the same MO is configured with both “ssb-ConfigMobility” and “csi-rs-ResourceConfigMobility, it counts as one frequency layer or 2 different frequency layers.
 |
| **Sub-topic#1-4** | **Issue 1-4-1: number of CSI-RS resource/beams to be monitored for each intra-f and inter-f layer***Tentative agreements:** Define number of CSI-RS resource/beams to be monitored for each intra-f and inter-f layer based on majority views, leaving the values in [] for further decision/ confirmation.
	+ - [14] CSI-RS resources for intra frequency measurements in FR1
		- [24] CSI-RS resources for intra frequency measurements in FR2,
		- [7] CSI-RS resources for inter frequency measurements in FR1,
		- [10] CSI-RS resources for inter frequency measurements in FR2.

*Candidate options:** + CSI-RS resources for each intra frequency layer in FR1
		- Option 1: 14 (MTK, OPPO, Apple, Nokia)
		- Option 2: 16 (Qualcomm)
		- Option 3: 24 (ZTE, CATT)
		- Option 4: 32 (CMCC, Huawei)
	+ CSI-RS resources for each intra frequency layer in FR2
		- Option 1: 24 (MTK, OPPO, Apple, Nokia, Huawei, Qualcomm, CATT)
		- Option 2: 42 (CMCC)
		- Option 3: 48 (ZTE)
		- Option 4: 32 (Huawei)
	+ CSI-RS resources for each inter frequency layer in FR1
		- Option 1: 7 (MTK, OPPO, Apple)
		- Option 2: 16 (ZTE, Qualcomm)
		- Option 3: 24 (CMCC, CATT, Huawei)
	+ CSI-RS resources for each inter frequency layer in FR2
		- Option 1: 10 (MTK, OPPO, Apple)
		- Option 2: 16 (Qualcomm)
		- Option 3: 24 (ZTE, Huawei, CATT)
		- Option 4: 34 (CMCC)

*Recommendations for 2nd round:*Continue discussion.* FFS whether and how the capability can be shared between SSBs and CSI-RS resources.

**Issue 1-4-2: CSI-RS resource/beams to be monitored for FR2 intra-f layer***Tentative agreements:** FFS: Per FR2 band, intra-f CSI-RS measurement for neighbour cells is only required for PCell/PSCell or one of SCell if there is no PCell/PSCell on that band
* UE shall also be capable of at least 2 SSBs and 2 CSI-RS resources on serving cell per CC in the same band.

*Recommendations for 2nd round:*Continue discussion if needed. Double confirmation is expected on the ’FFS’ in 1st bullet in this meeting. Compromises are expected from ZTE and Qualcomm on *Tentative agreements.*  |
| **Sub-topic#1-5** | **Issue 1-5-1: UE capability to indicate maximum number of CSI-RS resources in a slot per MO***Tentative agreements:**Option 2:* The total number of CSI resources that UE can monitor per slot is indicated by existing capability *maxNumberCSI-RS-RRM-RS-SINR.**Candidate options:** *Option 1/3: 2 companies*
* *Option 2: 6 companies*

*Recommendations for 2nd round:*Continue discussion if needed on how to split up from UE capability maxNumberCSI-RS-RRM-RS-SINR.**Issue 1-5-2:** the requirements when number of configured CSI-RS resources per slot exceeds the indicated UE capability.*Tentative agreements:* *No requirements when* number of configured CSI-RS resources per slot exceeds the indicated UE capability.**Issue 1-5-3: whether to introduce minimum separation between two slots with CSI-RS resources***Tentative agreements:* Not introduce UE capability. FFS the relation with time domain limitation*Candidate options:** *Option 2: 2 companies*
* *Option 3: 5 companies*

*Recommendations for 2nd round:*FFS the relation with time domain limitation. No discussion is needed if we conclude on clear time domain limitation of the CSI-RS per MO**Issue 1-5-4: Minimum symbol separation between CSI-RS resources in two consecutive slots** *Tentative agreements: None**Recommendations for 2nd round: FFS* |
| **Sub-topic#1-6** | **Issue 1-6-1: Whether to introduce restriction on CSI-RS MO configuration***Tentative agreements:None* *Candidate options:** *Option 1: Yes， 6 companies (Vivo, MTK, Intel, Qualcomm, Apple, OPPO)*
* *Option 2: No， 6 companies(CATT, ZTE, Huawei, Nokia, CMCC, Docomo)*

*Recommendations for 2nd round:*Continue discussion. * FFS introduce restriction on CSI-RS configuration, or define requirements for some scenario/configuration

**Issue 1-6-2: How to introduce time-domain restriction on CSI-RS resources configuration***Tentative agreements: Pending on issue 1-6-1.**Candidate options:** Alt1: introduce the restriction (CSI-RS resources are configured in 5ms window) when defining the requirement in RAN4 other than introducing new signaling due to time limit.
* Alt2: introduce CMTC
* Alt3: Limit CSI-RS resources to be confined in the SMTC duration of the same MO.

*Recommendations for 2nd round:*Continue discussion based on the proposed WF by Apple.* + In R16, Confine CSI-RS resources within SMTC of the associatedSSB and the corresponding periodicity of the SMTC should not be more than 40ms
		- * Up to 2 CSI-RS periodicities can be configured per CSI-RS intra-frequency layer
			* Up to 1 CSI-RS periodicity can be configured per CSI-RS inter-frequency layer
			* The candidate CSI-RS periodicities for L3 measurement are [10,20,40]ms
	+ Introduce CMTC in R17
 |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 | WF on CSI-RS based L3 measurement capability and requirements | OPPO |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Measurement requirements for CSI-RS intra-frequency and inter-frequency measurements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2006226**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006226.zip) | CATT | **Proposal 1: For CSI-RS based measurement requirement, the following scenarios are prioritized to be defined in Rel-16:** * **Intra-frequency measurement without gap**
* **Inter-frequency measurement with gap**

**Proposal 2: If associated SSB is configured for CSI-RS resources, the CSI-RS identification time can be expressed as follows:****T CSI-RS\_identify\_intra\_without\_index = (TPSS/SSS\_sync\_intra + T CSI-RS\_measurement\_period\_intra) ms****T CSI-RS\_identify\_intra\_with\_index = (TPSS/SSS\_sync\_intra + T CSI-RS\_measurement\_period\_intra + TSSB\_time\_index\_intra) ms****Proposal 3: The scaling factor due to Rx beam sweeping for CSI-RS measurement is defined as 8 in FR2.****Proposal 4: It is proposed to introduce the UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell.****Proposal 5: the scheduling restriction for CSI-RS based measurement shall be introduced for the following cases:**1. **Mix-numerology between data/SSB of serving cell and CSI-RS of neighbour cell**
2. **RX beam sweeping in FR2**
3. **Collision between UL transmission and DL measurement for TDD carrier**

**Proposal 6: If additional dedicated searcher is assumed for CSI-RS measurement, no impact on existing CSSF defined for SSB based measurement specified in 38.133. Otherwise, the CSSFs for FR1/FR2 SCC shall be updated by considering the CSI-RS based intra-frequency and inter-frequency measurement without gap and within gap respectively.** |
| [**R4-2006575**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006575.zip) | MediaTek inc. | **Observation 1: The introducing of the CSI-RS based requirement may have impact to existing SSB-based requirement.****Observation 2: The purpose of PBCH decoding is to acquire the frame and slot timing of the target cell.****Proposal 1: RAN4 to first conclude the time-domain limitation before discussing CSSF requirement.****Proposal 2: All CSI-RS in the same MO should follow the same time-domain relation with gap, e.g., either fully overlapped with gap, partially overlapped with gap or fully non-overlapped with gap.****Proposal 3: The easiest way to minimize the impact to existing SSB-based measurement requirement is to limit CSI-RS resources to be confined in the SMTC duration of the same MO.****Proposal 4: For PBCH, 5 samples are needed to guarantee >90% detection rate at SNR -6dB. If UE already detects the SSB of the target cell and deriveSSB-IndexFromCell is indicated, then UE may skip PBCH decoding.****Proposal 5: For inter-frequency CSI-RS measurement, at least additional [3] AGC samples are needed.****Proposal 6: All inter-frequency measurements are gap-assisted.****Proposal 7: Given the agreement in R4-2005355, all intra-frequency measurements are gapless.****Proposal 8: RAN4 should only introduce UE capability for simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell with different numerology if this scenario is confirmed to be important. Otherwise, RAN4 should leave it with no requirement.****Proposal 9: The FFT window timing always follows the serving cell timing for intra frequency measurement and is up to UE implementation for inter frequency measurement.****Proposal 10: The scheduling restriction on the additional OFDM symbols before and after CSI-RS are not needed.** |
| [**R4-2006765**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006765.zip) | CMCC | ***Proposal 1: for the case that cell search via SSB and PBCH decoding are needed, the time period for PSS/SSS detection and time period for time index detection (the terminology may need to be updated to apply to PBCH decoding) specified for SSB based mobility can be reused.******Proposal 2: for intra-frequency measurement, the measurement delay is proposed to be 3 samples.******Proposal 3: for inter-frequency measurement, the measurement delay is proposed to be 6 samples.*** |
| [**R4-2006841**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006841.zip) | LG Electronics Inc. | * ***Proposal 1***: Tight synchronization level between serving and neighbour cell should be considered to utilize CSI-RS L3 measurement.
* ***Proposal 2***: Tight synchronization level less than CP length is needed to support different SCS value.
* ***Proposal 3***: Re-use the principle of SSB based L3-measurement for scaling factor N which could be up to 8.
* ***Proposal 4:*** Define scheduling restriction on one data symbol before and after CSI-RS symbol to be measured.
* ***Proposal 5:*** Do not define scheduling restriction if the timing difference between serving and neighbor cell including cell phase synchronization is guaranteed to be less then CP length
* ***Proposal 6:*** Network should configure L1 measurement resource to avoid collision with CSI-RS L3 measurement resource of neighbour cell.
 |
| [**R4-2006951**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006951.zip) | NTT DOCOMO, INC. | **Observation 1: According to the definition of cell phase synchronization accuracy, the difference of frame start timing between two intra-frequency cells can be allowed if its value is less than 3us.****Observation 2: MRTD requirement for intra-band CA is 3us.****Observation 3: If deriveSSB-IndexFromCell is indicated, UE assumes that the neighbour cell is synchronous with the serving cell and the serving cell timing can be derived from the index of the SSB transmitted by the neighbour cell.****Observation 4: In the case of SSB based intra-frequency measurement, scheduling restriction is applied to 1 data symbol before and after SSB symbols.****Proposal 1: The timing error between the serving cell and the neighbor cell should be less than 3us.****Proposal 2: Select either two options about synchronization assumption for both of the cases of with/without associated SSB. (option 2 and 3 for the case without associated SSB and option 3 and 4 for the case with associated SSB)*** + **the timing error is less than [X]us, where X is 3~4us**
	+ **MRTD value for intra-band CA can be reused.**

**Proposal 3: PBCH decoding on target cell is not necessary regardless of associatedSSB when deriveSSB-IndexFromCell is indicated.****Proposal 4: To align with the case of SSB, select option 2:*** **Option 2 : The scheduling restriction on the additional OFDM symbols before and after SSB is not needed.**
 |
| [**R4-2007101**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007101.zip) | Nokia, Nokia Shanghai Bell | **Proposal1: Gaps are not needed for intra-frequency CSI-RS based measurement.** **Proposal2: It is up to RAN2 to discuss whether CSI-RS based measurement window is required or not.** **Proposal3: The CSI-RS based RRM measurement is at least restricted by DRX configuration in time domain.** **Proposal4: The CSI-RS based intra-frequency cell identification comprises SSB-based cell identification and CSI-RS based measurements, where SSB-based cell identification is the same as the intra-frequency cell identification for SSB-based measurement.****Proposal5: Within the CSI-RS based intra-frequency cell identification, the time period to detect the *associatedSSB* can reuse Tidentify\_intra\_with\_index as defined in [3].****Proposal6: The CSI-RS based measurement period for intra-frequency measurement is defined based on 3 samples for {D=3 & 48PRB} and {D=1 & 96PRB} given SNR = -6dB.**  |
| [**R4-2007356**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007356.zip) | OPPO | ***Proposal 1: No requirements is specified for CSI-RS L3 measurement when associatedSSB is not configured.******Proposal 2: No requirement is defined for the case the MO doesn’t include the serving CSI-RS resource regardless of CSI-RS resource associated SSB configured or not.******Proposal 3:******For intra-frequency CSI-RS based measurements, UE can perform intra-frequency CSI-RS based measurements without measurement gaps if*** * ***CSI-RS resource is completely contained in the active BWP of the UE.***

***Proposal 4: For inter-frequency CSI-RS based measurements, UE will need GAPs if**** ***SCS of CSI-RS is different from active BWP if UE is not capable of mixed numerology, and/or***
* ***CSI-RS resource is not fully confined within the active BWP, and/or***
* ***CP of cells to be measured is different from that of active BWP***

***Proposal 5: If a new capability for UE supporting different SCS in source and target cells is defined in Rel-16 NR mobility measurement, reuse it for CSI-RS L3 measurement.******Proposal 6: If UE already detects the SSB of the target cell and deriveSSB-IndexFromCell is indicated, PBCH decoding can be skipped.******Proposal 7: Support to introduce CMTC for restriction on time-domain for CSI-RS resource.******Proposal 8: Reuse values of SSB samples for intra-frequency and inter-frequency CSI-RS L3 measurements.******Proposal 9: When UE performs CSI-RS intra-frequency measurements in a FR1 TDD band, UE is not expected to transmit and receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.******Proposal 10: If UE is not able to support mixed numerology of data and CSI-RS L3 mobility, the following scheduling restrictions apply due to intra-frequency CSI-RS based L3 measurement:**** + - ***if the associatedSSB is configured, UE is not expected to transmit or receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.***
		- ***if the associatedSSB is not configured, no requirements apply.***
 |
| [**R4-2007736**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007736.zip) | Huawei, Hisilicon | ***Proposal 1: No requirements are specified if associatedSSB is not configured for CSI-RS.******Proposal 2: For intra-frequency CSI-RS measurement******-For FR1 FDD, UE needs to perform PSS/SSS detection, PBCH decoding and intra-frequency CSI-RS measurement.******-For FR1 TDD or FR2, UE needs to perform PSS/SSS detection and the intra-frequency CSI-RS measurement.******For inter-frequency CSI-RS measurement******-For FR1 FDD, UE needs to perform PSS/SSS detection, DMRS matching and PBCH decoding and inter-frequency CSI-RS measurement.******-For FR1 TDD and FR2, UE shall perform PSS/SSS detection, PBCH decoding and inter-frequency CSI-RS measurement.******Proposal 3: AGC adjustment time shall be considered when UE needs to retune RF to an inter-frequency layer to perform measurement.******Proposal 4: The agreement ‘If the CSI-RS is QCL-ed to the associated SSB, no Rx sweeping is needed only after SSB has been detected’ shall be carefully analysed, especially in the case that the multiple CSI-RS resources from different cells are transmitted in the same OFDM symbols in one MO, and the CSI-RS resources are QCL-ed with different associated SSB.******Proposal 5: If a UE is configured with both CSI-RS-Resource-Mobility and ssb-ConfigMobility in one MO, the CSSF calculation shall consider SSB MO and CSI-RS MO.******Proposal 6: There is no requirements if associatedSSB is not included in ssb-ToMeasure in SSB-ConfigMobility in the same MO.******Proposal 7: The requirements for CSI-RS based measurement can consider a full set of the following scenarios:**** ***Intra-frequency without gap***
* ***Intra-frequency with gap***
* ***Inter-frequency without gap***
* ***Inter-frequency with gap***

***Proposal 8: The UE will need GAPs for CSI-RS L3 measurements if******• The CSI-RS is not fully confined within the active BWP******• The CP of cells to be measured is different from that of active BWP (60 kHz SCS only)******Proposal 9: The tuning time for CSI-RS based measurements that are outside UE’s active BWP can be defined as a UE capability.******Proposal 10: If UE is not able to support mixed numerology of data and CSI-RS L3 mobility, if the associatedSSB is configured, UE is not expected to transmit or receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.******Proposal 11: If UE can perform CSI-RS based measurement independently with SSB based measurement, no scheduling restriction shall be configured.******Proposal 12: When UE performs CSI-RS intra-frequency measurements in a TDD band, UE is not expected to transmit and receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.******Proposal 13: Scheduling restriction shall be considered when UE performs RX beam sweeping.*** |
| [**R4-2008237**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2008237.zip) | Qualcomm CDMA Technologies | **Proposal4: If CSI-RS configured with associated SSB but not QCL-ed to the associated SSB, the UE Rx sweeping scaling factor N=2 or 4.****Proposal4.1: in view of the cost and Rel-16 timeline, we propose Rel-16 doesnot define requirements for this scenario when associated SSB is not QCLed with CSI-RS. (part of our proposal 3)**Observation3: The tuning time of inter-frequency GAP of CSI-RS measurement shall be longer than the gap switch time for measuring the inter-frequency SSBs. **Proposal5: extra margin needs to be reserved for GAP tune-in time for processing CSI-RS inter-frequency measurements.****Proposal6: L1 measurement resource shall be configured to avoid collision with CSI-RS L3 measurement resource of neighbour cell as stated in Option 2 if UE doesnot support simultaneous SSB and neighbor CSI-RS reception.****Proposal6.1: Define a new UE capability for simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell.****Proposal7: Collision shall be avoided between CSI-RS/PDCCH/PDSCH of the serving cell and CSI-RS L3 measurement resource of neighbour cell.** **Proposal8: As a further restriction for TDD, it is reasonable that UE shall not transmit during reception of the neighbor cell CSI-RS due to UL/DL collision caused by measuring neighbor CSI-RS.**  |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

|  |
| --- |
| **WF on measurement requirements for Case 1 if associatedSSB is not configured for CSI-RS*** + Option 1 (MTK, Apple, Intel, Huawei, Qualcomm, Nokia, OPPO, CATT, ZTE):
		- No requirements in Rel-16.
	+ Option 2 (DOCOMO, CMCC):
		- the requirement needs at least consider the CSI-RS measurement time, if associatedSSB is not configured, assuming UE shall base the timing on its serving cell (indicated by refServCellIndex or PCell)

**WF on measurement requirements for Case 2 if associatedSSB is configured for CSI-RS*** Agreements: CSI-RS based cell identification can consider
	+ 1) Cell search via SSB, 2) PBCH decoding and 3) CSI-RS measurement.
	+ If configured SSB fails to be detected, requirement should not be defined.
* FFS: If UE already detects the SSB of the target cell and deriveSSB-IndexFromCell is indicated, PBCH decoding can be skipped.
* FFS: the working assumption of single FFT window and whether to define a capability.
* FFS the requirements for the cases
	+ If the MO includes the serving CSI-RS resource with associated SSB
	+ if the MO doesn’t include the serving CSI-RS resource and the CSI-RS resource associated SSB is configured
* FFS AGC adjustment time.
* FFS CSSF
* FFS scheduling restriction

**WF on requirements of Measurement Gap**More discussion based on the options as below in next meeting.* Requirements with or w/o gaps
	+ Option 1 : For CSI-RS based measurement requirement, the following scenarios are prioritized to be defined in Rel-16:
		- Intra-frequency measurement without gap
		- Inter-frequency measurement with gap
* The principle for gap-needed or gapless
	+ Option 1: The UE will need GAPs for CSI-RS L3 measurements if
		- The SCS of CSI-RS is different from active BWP [if UE is not capable of mixed numerology]
		- The CSI-RS is not fully confined within the active BWP
		- The CP of cells to be measured is different from that of active BWP (60 kHz SCS only)
	+ FFS : The tuning time for CSI-RS based measurements that are outside UE’s active BWP will be same as that for BWP switch.

**WF on Collision between L1 measurement of serving cell and CSI-RS L3 measurement of neighbour cell*** Option 1(LGE, MTK, OPPO, Apple):
	+ Do not define CSI-RS measurement requirements for the collision case.
* Option 2(LGE, MTK, Qualcomm, OPPO, ZTE, Huawei):
	+ Network should configure L1 measurement resource to avoid collision with CSI-RS L3 measurement resource of neighbour cell.

**Whether to introduce the UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell** * Option 1(OPPO, CATT, MTK, Apple,Huawei, Qualcomm): New UE capability
* Option 2: Reusing SimultaneousRxDataSSB-DiffNumerology
* Option 3(MTK, ZTE): Do not consider the case mix-numerology between data/SSB of serving cell and CSI-RS of neighbour cell

**WF on Scheduling restriction*** Option 1 (Huawei):
	+ If UE is not able to support mixed numerology of data and CSI-RS L3 mobility, the following scheduling restrictions apply due to intra-frequency CSI-RS based L3 measurement:
	+ if the associatedSSB is configured, UE is not expected to transmit or receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.
	+ if the associatedSSB is not configured, UE is not expected to transmit or receive on the data OFDM symbol impacted by CSI-RS resource symbol to be measured, provided timing difference between the CSI-RS resource and the serving cell should be less than half CP corresponding to the SCS of the CSI-RS.
	+ When UE performs CSI-RS intra-frequency measurements in a TDD band, UE is not expected to transmit and receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.
	+ Scheduling restriction shall be considered when UE performs RX beam sweeping.
* Option 2 (MediaTek, DOCOMO):
	+ The scheduling restriction on the additional OFDM symbols before and after SSB is not needed.
* Option 3 (LGE, Apple):
	+ Define scheduling restriction on one data symbol before and after CSI-RS symbol to be measured due to Rx beam sweeping.
	+ Do not define scheduling restriction if the timing difference between serving and neighbor cell including cell phase synchronization is guaranteed to be less than CP length
* Do not preclude other options(Qualcomm)
 |

### Sub-topic 2-1: General

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 2-1-1: Whether to define requirements related to associated SSB**

* Proposals
	+ Option 1: No requirements shall be defined in Rel-16 for CSI-RS L3 measurement, when
1. associated SSB is not configured
2. associated SSB is not detected even if associated SSB is configured
3. associated SSB is not QCLed with CSI-RS
4. associated SSB is configured and detected but the corresponding target cell timing has a large delta from the UE’s serving cell timing.
5. associated SSB is not included in ssb-ToMeasure in SSB-ConfigMobility in the same MO.
* Recommended WF
	+ Tentative agreement:
		- Collect views on component 1~5 and suggest to agree on at least 1~3 in 1st round

**Issue 2-1-2: Whether to define requirements related to the serving CSI-RS resource and MO configuration**

* Proposals
	+ Option 1: No requirement for the case MO doesn’t include the serving CSI-RS resource.
	+ Option 2: No requirement if serving cell CSI-RS is not available due to missing servingCellMO.
* Recommended WF
	+ Assuming Email thread [225] can cover this issue, no more discussion is needed in this email thread [226].

**Issue 2-1-3: Conditions for gap-needed or gapless**

* Proposals
	+ Option 1:
		- All inter-frequency measurements are gap-assisted.
		- All intra-frequency measurements are gapless.
	+ Option 2:
		- For intra-frequency CSI-RS based measurements, UE can perform intra-frequency CSI-RS based measurements without measurement gaps if
			* CSI-RS resource is completely contained in the active BWP of the UE.
		- For inter-frequency CSI-RS based measurements, UE will need GAPs if
			* SCS of CSI-RS is different from active BWP if UE is not capable of mixed numerology, and/or
			* CSI-RS resource is not fully confined within the active BWP, and/or
			* CP of cells to be measured is different from that of active BWP
	+ Option 3:
		- The UE will need GAPs for CSI-RS L3 measurements if
			* The CSI-RS is not fully confined within the active BWP
			* The CP of cells to be measured is different from that of active BWP (60 kHz SCS only)
* Recommended WF
	+ Option 2 and 3 are suggested to be merged.

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| **Issue 2-1-1: Whether to define requirements related to associated SSB** |
| **Company** | **Comments** |
| vivo | Regarding to 1), this is the agreement in last meeting.Regarding to 2), this is nature and should be supported.Regarding to 3), in our view no QCL is configured for CSI-RS in the “csi-rs-ResourceConfigMobility” and we are not sure what does this bullet refers to.Regarding to 4), we are fine to discuss that in the performance phase.Regarding to 5), we believe it should have requirement, especially for the case that “ssb-ConfigMobility” is not configured in one MO. |
| MTK | 1. OK
2. OK
3. OK for FR2, but not sure if we also need this in FR1
4. This is the issue to be discussed in performance part
5. OK. Some clarification should be done here.
	* If ssb-ToMeasure is not configured, UE has to detect all SSBs within SMTC duration. In this case, there is no problem to specify requirement.
	* If ssb-ToMeasure is configured, but the bit corresponding to the associated SSB is not toggled, then UE will not even try to detect that SSB. As a result, no CSI-RS requirement should be specified.
 |
| CATT | 1. OK
2. It is up to UE.
3. We support to define requirement for non-QCL-ed case.
4. It depends on the conclusion on synchronization assumption
5. OK.
 |
| Intel | support 1~3. |
| ZTE | 1. OK
2. OK.
3. Both QCL-ed and not QCL-ed should be allowed. AssociatedSSB is mainly used for timing reference.
4. FFS

It is unclear what the same MO means. It is fine if ‘associated SSB is not included in ssb-ToMeasure in SSB-ConfigMobility’. |
| Huawei | 1. Ok
2. Ok
3. No. If associated SSB is not QCLed with CSI-RS, UE may need to perform beam sweeping. The requirements can be specified.

Regarding the associated SSB QCLed with CSI-RS, a special case shall be noted that multiple CSI-RS resources from different cells are transmitted in the same OFDM symbols in one MO, and the CSI-RS resources are QCL-ed with different associated SSB. We propose there are no requirements for this case.1. No. UE needs to detect the associatedSSB regardless the timing difference between the target timing and serving cell.
2. Ok.
 |
| Nokia, Nokia Shanghai Bell | We agree with Option 1- 1),2)3). For 4), the UE uses the timing of the cell to be measured when associatedSSB is configured. The timing difference between neighbor and serving cells does not impact the measurement performance if MRTD requirement is fulfilled. For 5), associatedSSB needs anyway to be detected no matter SSB-based mobility is configured. Such restriction is not necessary.  |
| LG | We support option 1) and 2).For option 3), we don’t have strong view. However, if the requirement for ‘case 3) associated SSB is not QCLed with CSI-RS’ is defined especially in FR 2, the scaling factor N for Rx beam sweeping need to be considered.For option 4), we think that it depends on the conclusion of synchronization assumption. |
| Qualcomm | For option 1, we support 1), 2), 3), 5). |
| Apple | We support 1,2,3,5. 4) seems unnecessary.  |
| OPPO | Support 1), 2), 3), 5). FFS on 4) |
| Docomo | 1. OK. As vivo said, this was the agreement at the previous meeting.
2. OK. In TS38.331, it is clearly described that if the UE failed to detect the SSB indicated by associatedSSB, the UE is not required to monitor the CSI-RS resources related to the SSB
3. No. We prefer to define requirements for this case because this case is possible.
4. This case seems to depend on the conclusion of synchronization assumption.
5. OK. We think the associated SSB and the SSB to be measured should be considered separately.
 |

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| **Issue 2-1-2: Whether to define requirements for the case MO doesn’t include the serving CSI-RS resource** |
| **Company** | **Comments** |
| MTK | Pending on the discussion in [225] |
| ZTE | Duplicated discussion |
| Huawei | Discussed in mail thread [225] |
| Qualcomm | Option2 is supported. |
| OPPO | Agree with the recommended WF and wait for the conclusion from [225]. |
| Docomo | Agree with the recommended WF. |

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| **Issue 2-1-3: Conditions for gap-needed or gapless** |
| **Company** | **Comments** |
| vivo | We support option 1 for R16. |
| MTK | Support Option 1. Other cases can be left to later releases for enhancement. |
| CATT | Ok with option 1. |
| Intel | fine with option 1. |
| ZTE | In rel-16, Option 1. Enhancement is needed in later releases. |
| Huawei | Support option 3.  |
| Nokia, Nokia Shanghai Bell | Based on current definition and requirement scope of intra-frequency measurements, the intra-frequency measurement is always gap-less. For inter-frequency measurement, we may prioritize the study on inter-frequency measurement with gaps, and wait for the progress in Rel16 RRM Enhancements on inter-f without gaps.  |
| Qualcomm | Option1 is supported. |
| Apple | Option 1. |
| CMCC | Considering limited timeline, we can accept to define requirements only for intra-f without gap and inter-f with gap in Rel-16. |
| OPPO | Support option 1.  |
| Docomo | Agree with option 1. |

### Sub-topic 2-2: Measurement delay

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 2-2-1: Cell identification time**

* Proposals
	+ Option 1:
		- If associated SSB is configured for CSI-RS resources, the CSI-RS intra-frequency cell identification time can be expressed as follows:
* T CSI-RS\_identify\_intra\_without\_index = (TPSS/SSS\_sync\_intra + T CSI-RS\_measurement\_period\_intra) ms
* T CSI-RS\_identify\_intra\_with\_index = (TPSS/SSS\_sync\_intra + T CSI-RS\_measurement\_period\_intra + TSSB\_time\_index\_intra) ms
	+ - The CSI-RS based intra-frequency cell identification comprises SSB-based cell identification and CSI-RS based measurements, where SSB-based cell identification is the same as the intra-frequency cell identification for SSB-based measurement.
		- For the time period for PSS/SSS detection and for time index detection, values for SSB based mobility (TPSS/SSS\_sync\_intra and TSSB\_time\_index\_intra )can be reused for the case that cell search via SSB and PBCH decoding are needed
	+ Option 2:



* Figure 1. Time flow for CSI-RS based cell identification
	+ - For PBCH decoding, 5 samples are needed to guarantee >90% detection rate at SNR -6dB.
		- If UE already detects the SSB of the target cell and deriveSSB-IndexFromCell is indicated, then UE can skip PBCH decoding.
	+ Option 3:
		- For intra-frequency CSI-RS measurement
			* For FR1 FDD, UE needs to perform PSS/SSS detection, PBCH decoding and intra-frequency CSI-RS measurement.
			* For FR1 TDD or FR2, UE needs to perform PSS/SSS detection and the intra-frequency CSI-RS measurement.
		- For inter-frequency CSI-RS measurement
			* For FR1 FDD, UE needs to perform PSS/SSS detection, DMRS matching and PBCH decoding and inter-frequency CSI-RS measurement.
			* For FR1 TDD and FR2, UE shall perform PSS/SSS detection, PBCH decoding and inter-frequency CSI-RS measurement.
		- AGC adjustment time shall be considered when UE needs to retune RF to an inter-frequency layer to perform measurement.
	+ Option 4：
		- PBCH decoding on target cell is not necessary regardless of associatedSSB when deriveSSB-IndexFromCell is indicated.
* Recommended WF
	+ For intra-frequency CSI-RS measurement, Option 1 can be agreed as basic framework of cell identification time for CSI-RS intra-f measurement. And TPSS/SSS\_sync\_intra and TSSB\_time\_index\_intra can be reused.
		- For intra-frequency CSI-RS measurement
			* T CSI-RS\_identify\_intra\_without\_index = (TPSS/SSS\_sync\_intra + T CSI-RS\_measurement\_period\_intra) ms
			* T CSI-RS\_identify\_intra\_with\_index =(TPSS/SSS\_sync\_intra + T CSI-RS\_measurement\_period\_intra + TSSB\_time\_index\_intra) ms
	+ **FFS** inter-frequency CSI-RS measurement.
		- Alt1: the framework for intra-f can be reused
		- Alt2: for inter-frequency CSI-RS measurement (from option 3)
			* For FR1 FDD, UE needs to perform PSS/SSS detection, DMRS matching and PBCH decoding and inter-frequency CSI-RS measurement.
			* For FR1 TDD and FR2, UE shall perform PSS/SSS detection, PBCH decoding and inter-frequency CSI-RS measurement.
	+ For PBCH decoding, Option 2/3/4 are not contradictory with other options, which can be merged as common understanding：
		- If UE already detects the SSB of the target cell and deriveSSB-IndexFromCell is indicated, UE can skip PBCH decoding.

**Issue 2-2-2: CSI-RS measurement period**

* Proposals
	+ Option 1:
		- Reuse SSB samples for intra-frequency and inter-frequency CSI-RS L3 measurements period.
	+ Option 2:
		- For intra-frequency measurement period: 3 samples
		- For inter-frequency measurement period: 6 samples
	+ Option 3:
		- The CSI-RS based measurement period for intra-frequency measurement is defined based on 3 samples for {D=3 & 48PRB} and {D=1 & 96PRB} given SNR = -6dB.
* Recommended WF
	+ Option 1

**Issue 2-2-3: the tuning time for CSI-RS based measurements**

* Proposals
	+ Option 1:
		- The tuning time of inter-frequency GAP of CSI-RS measurement shall be longer than the gap switch time for measuring the inter-frequency SSBs.
		- Extra margin needs to be reserved for GAP tune-in time for processing CSI-RS inter-frequency measurements.
	+ Option 2:
		- The tuning time for CSI-RS based measurements that are outside UE’s active BWP can be defined as a UE capability.
* Recommended WF
	+ Pending on the conclusion of intra and inter-frequency definition.
	+ If agreed on UE capability, an LS to RAN2 should be considered.

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| **Issue 2-2-1: Cell identification time** |
| **Company** | **Comments** |
| vivo | We are fine with the recommend WF. |
| MTK | Option 2, 3 and 4 are fine to us.Regarding Option 1, we are not sure why we need 2 requirements for without index and with index. |
| ZTE | Option 2 is reasonable in general. In addition if associatedSSB has been detected a certain of time ago, then cell detection and PBCH decoding is not be needed. |
| Huawei | Option 3 with minor correction:For intra-frequency CSI-RS measurement:* For FR1 FDD without *deriveSSB-IndexFromCell*, UE needs to perform PSS/SSS detection, PBCH decoding and intra-frequency CSI-RS measurement.
* For FR1 FDD with *deriveSSB-IndexFromCell* enabled, FR1 TDD or FR2, UE needs to perform PSS/SSS detection and the intra-frequency CSI-RS measurement.

In option 1, the condition of “without index” and “with index” are not clear. |
| Nokia, Nokia Shanghai Bell | In principle, we are fine with Option 1.We are a bit concerned on T CSI-RS\_identify\_intra\_without\_index. As the UE need detect associatedSSB before measuring CSI-RS, the time to acquire SSB index is then required. Do we still need consider the case of T CSI-RS\_identify\_intra\_without\_index? |
| Qualcomm | Option1 is supported. |
| Apple | Option 1 and 4. For option 3, SSB based cell measurement is needed too to confirm the corresponding cell detection is correct.  |
| OPPO | Option 1 and 4. And 2nd bullet of option 2 is also ok. |
| Docomo | Although we mostly agree with the recommended WF, we want to clarify the meaning of “as common understanding”. Does it mean that the description of “If UE already detects the SSB of the target cell and deriveSSB-IndexFromCell is indicated, UE can skip PBCH decoding” can be considered as agreed? If the answer is yes, we fully agree with the recommended WF. Otherwise, option 2, 3 and 4 are fine for us. |

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| **Issue 2-2-2: CSI-RS measurement period** |
| **Company** | **Comments** |
| vivo | We are fine with the recommended WF. |
| MTK | Support Option 1  |
| CATT | Option 1 |
| Intel | prefer option 1 |
| ZTE | Option 3. The number of samples can be further discussed. |
| Huawei | Agree with the recommended WF |
| Nokia, Nokia Shanghai Bell | We prefer Option 3. The different configurations need to be defined for the single requirements. About the number of samples, CSI-RS measurement is averaged over more Res comparing to SSB, 3 samples can already achieve comparable performance with SSB-based measurement from the simulation. Are we expecting better accuracy with 5 samples for CSI-RS based measurements?  |
| Qualcomm | Recommended WF is agreeable as a baseline for both FR1 and FR2Option2 reserves 3 more samples for AGC adjustment in the case of inter frequency which needs to be agreed. |
| Apple | Option 1.  |
| CMCC | Firstly, we would like to know how to decide the number of samples for measurement. It is related to the measurement accuracy, in our view, at least, the measurement accuracy of CSI-RS is no worse than the measurement accuracy of SSB measurementIn our contribution, same measurement accuracy of SSB is assumed, with this assumption, according to our simulation results, 3 samples for intra-frequency measurement is proposed. We would like to know companies’ assumption on measurement accuracy which propose to reuse the number of samples for SSB measurement. |
| OPPO | Support option 1. |
| Docomo | Agree with the recommended WF |

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| **Issue 2-2-3: the tuning time for CSI-RS based measurements** |
| **Company** | **Comments** |
| vivo | For the case CSI-RS is confined in SMTC, the tuning time can be the same as SSB-based requirement. |
| MTK | Option 1 is fine to us. Option 2 is pending on the conclusion of other parallel discussion. For an example, if gap is always assumed, then we can follow the RF re-tuning time of gap |
| ZTE | We don’t understand why gap running time is longer. |
| Huawei | From UE implementation perspective, the tuning time for CSI-RS measurement is the same AS GAP retuning time: one way 0.5ms. However there are different implementation.A trade-off is option 2, i.e., UE can report capability of tuning time. |
| Nokia, Nokia Shanghai Bell | Is this UE implementation matter? Would to be good to know how different are the tuning times from different vendors. |
| Qualcomm | Options 1 and 2 are not conflicting. So we support Option2 to introduce a UE capability to the network, which helps to align the SMTC window and GAP properly.To ZTE, GAP for SSB only requires suspending the serving data processor before invoking the searcher to process SSB. However, GAP for CSI-RS could require additional retuning operation of the same data processor to a new center frequency. Since it depends on the UE implementation, a UE capability is preferred.To Nokia, yes. |
| Apple | On option 1, it is not clear why tuning time for CSI-RS should be longer than inter-f SSB. Tuning time for inter-f SSB is borrowed from LTE. How CSI-RS makes different from others?Same concern on option 2. How it is different from inter-f SSB?  |
| CMCC | We would like to know why the tuning time of inter-frequency GAP of CSI-RS measurement shall be longer than the gap switch time for measuring the inter-frequency SSBs. |
| OPPO | More discussion could be needed. |
| Docomo | We have similar view as Huawei. The retuning time can be considered as same as the RF retuning time (0.5ms), we think.  |

### Sub-topic 2-3: Scaling Factor

*Sub-topic description*

CSSF and Scaling factor for RX beam sweeping are to be discussed in this section.

*Open issues and candidate options before e-meeting:*

**Issue 2-3-1: Whether dedicated searcher(s) is assumed for CSI-RS based measurement?**

* + Option1: Yes
	+ Option 2: No
* Recommended WF
	+ FFS.

**Issue 2-3-2: CSSF requirements**

* Proposals
	+ Option 1:
		- TBD before concluding the time-domain limitation
		- All CSI-RS in the same MO should follow the same time-domain relation with gap, e.g., either fully overlapped with gap, partially overlapped with gap or fully non-overlapped with gap
	+ Option 2:
		- If additional dedicated searcher is assumed for CSI-RS measurement, no impact on existing CSSF defined for SSB based measurement specified in 38.133.
		- Otherwise, the CSSFs for FR1/FR2 SCC shall be updated by considering the CSI-RS based intra-frequency and inter-frequency measurement without gap and within gap respectively.
	+ Option 3:
		- If a UE is configured with both CSI-RS-Resource-Mobility and ssb-ConfigMobility in one MO, the CSSF calculation shall consider SSB MO and CSI-RS MO.
* Recommended WF
	+ Pending on the conclusion on time-domain restriction.

**Issue 2-3-3: Scaling factor N for RX beam sweeping**

Agreement：If CSI-RS configured with associated SSB but not QCL-ed to the associated SSB, Rx sweeping is needed.

* FFS on the scaling factor N =8.
* Proposals
	+ Option 1: N=2 or 4
	+ Option 2: N=8
	+ Option 3 : Not define requirements when associated SSB is not QCLed with CSI-RS in Rel-16
* Recommended WF
	+ FFS

**Issue 2-3-4: RX beam sweeping when CSI-RS is QCL-ed to the associated SSB**

* Proposals
	+ Option 1: keep the last agreement
		- no Rx sweeping is needed
	+ Option 2: FFS especially in the case that the multiple CSI-RS resources from different cells are transmitted in the same OFDM symbols in one MO, and the CSI-RS resources are QCL-ed with different associated SSB.
* Recommended WF
	+ Option 1

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| **Issue 2-3-1: Whether dedicated searcher(s) is assumed for CSI-RS based measurement** |
| **Company** | **Comments** |
| MTK | Support Option 1.To us, it is very obvious that the engine for measurement is different. However, this does not mean that we can introduce the CSSF for CSI-RS which completely ignoring the SSB CSSF. For inter-frequency layer, UE can still pick one frequency layer at a time for either SSB or CSI-RS (or both) measurement. For intra-frequency layers in FR2, UE still face the Rx beam constraint that UE has to form one single Rx beam direction for the frequencies layers to be measured at the same time. |
| CATT | Support option 1, 1 dedicated searcher is assumed for CSI-RS based measurement. |
| ZTE | Support Option 1. |
| Huawei | From UE implementation perspective, dedicated searcher can be assumed for CSI-RS measurement. However before measuring on the CSI-RS, the associated SSB shall be first identified. Detecting associated SSB and other intra-f/inter-f SSB shall share the same searcher. In SSB based measurement requirements, CSSF is applied for both cell identification and measurement. For CSI-RS based measurements, if we consider dedicated searcher for CSI-RS and shared searcher for SSB, then the CSSF factor will be separate for the two parts. In summary, the answer of this issue doesn’t directly impact the calculation of CSSF.  |
| Qualcomm | CSI-RS processing does not share the searcher with SSB processing. It doesnot assume a conventional searcher architecture used for SSB either.  |
| Apple | It is not clear what the implications of the option 1 and 2. We cannot assume SSB and CSI-RS can always be done in parallel. In other words, scaling factor is needed.  |

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| **Issue 2-3-2: CSSF requirements** |
| **Company** | **Comments** |
| vivo | Agree with the recommended WF. |
| MTK | Agree with the recommended WF |
| Huawei | Agree with the recommended WF |
| Nokia, Nokia Shanghai Bell | We think we need align the assumptions for discussing the CSSF requirements. E.g. how many searchers are we assuming? Can the UE measure both CSI-RS and SSB in the same gap? We can leave more time for discussion.  |
| Qualcomm | Option1 is supported.The discussion is pending on the agreements on MO configuration as issue 1-6-2. For option2, our understanding is CSI-RS measurement doesnot compete searcher with SSB. So option2 can be resolved. Then it means CSSF needs to be defined for SSB and CSI-RS separately as CSSFSSB and CSSFCSIL3. |
| Apple | Agree with WF |
| OPPO | We can come back after clear decision on time-domain restriction. |
| Docomo | Agree with the recommended WF |

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| **Issue 2-3-3: Scaling factor N for RX beam sweeping** |
| **Company** | **Comments** |
| vivo | We are not sure what does the QCL here mean.If associated SSB is configured but CSI-RS cannot be detected based on the timing of associated SSB, no requirement is applied.Therefore we prefer option 3. |
| MTK | It seems that this whether to specify the value is pending on the conclusion of **Issue 2-1-1** |
| CATT | Option 2 |
| Intel | support option 3. Associated SSB and CSI-RS should have the same spatial filter, then the same Rx beam and DL timing can be used. |
| Huawei | Option 2 can be as a starting point. |
| Nokia, Nokia Shanghai Bell | This depends on the requirement scope discussion in Issue 2-3-1. We prefer not defining the requirements if associatedSSB is not QCLed with CSI-RS in Rel16.  |
| LG | We think that the scaling factor N for Rx beam sweeping depends on the conclusion of Issue 2-1-1. If the requirements for ‘case 3) associated SSB is not QCLed with CSI-RS’ in Issue 2-1-1 are defined, we prefer option 2. |
| Qualcomm | After reviewing other options, we agree with option 3. The concern is if QCL relationship doesnot hold, the timing error could be worse when UE does Rx beam sweeping. Since the accuracy is not ensured anyway, requirements shallnot be defined. Therefore, option3 is supported at least for Rel-16. As LG comments, it is related to case 3) in issue 2-1-1. |
| Apple | To simplify the discussion, support option 3 in R16. |
| OPPO | Support option 3. |
| Docomo | Option 1 and 2 are fine for us. |

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| **Issue 2-3-4: RX beam sweeping when CSI-RS is QCL-ed to the associated SSB** |
| **Company** | **Comments** |
| vivo | Agree with the recommended WF. |
| MTK | Option 2 is pointing out one key issue to be discussed. If UE needs to measure 2 CSI-RS from 2 cell with 2 different associated and QCL-ed SSBs, respectively. For Cell #1, the best Rx beam to measure the SSB is Rx beam #1, while for Cell #2, the best Rx beam to measure the SSB is Rx beam #2. Now when these 2 CSI-RS comes at the same OFDM symbol, which Rx beam should UE use to perform measurement?  |
| CATT | Agree with the recommended WF. |
| Intel | support recommended WF. |
| ZTE | No need to further discuss the agreements. The case pointed out by MTK can be further studied, maybe in next release. |
| Huawei | We can’t simply go to option1. The issue pointed out in option 2 needs to be resolved. The detail description of option 2 is in [R4-2007736].  |
| Nokia, Nokia Shanghai Bell | We agree with the recommended WF. |
| Qualcomm | Option1 is supported.For the issue shared in option2, we think it can be avoided by configuring the CSI-RS resources from multiple neighbor cells in the different MOs that can be measured at different times, which is up to NW implementation. Otherwise, no requirements should be defined. |
| Apple | We support option 1 but would like to clarify CSI-RS is QCL-ed type D to associated SSB |
| OPPO | Option 1. Agree with the clarification of QCL-ed as type D. |
| Docomo | Agree with the recommended WF. We have already concluded this issue in the previous meeting. |

### Sub-topic 2-4: UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell

*Sub-topic description*

* The requirements for scheduling restriction are only defined for CSI-RS L3 measurement without gaps
* Identify all possible factors which would cause scheduling restriction in next meeting:
	+ Collision with UL transmission and DL measurement on TDD carrier
	+ The need of Rx beam sweeping in FR2
	+ Mix-numerology between data/SSB of serving cell and CSI-RS of neighbour cell

*Open issues and candidate options before e-meeting:*

**Issue 2-4-1: Whether to introduce UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell**

* Proposals
	+ Option 1: New UE capability
	+ Option 2: Reusing *SimultaneousRxDataSSB-DiffNumerology*
	+ Option 3: If a new capability for UE supporting different SCS in source and target cells is defined in Rel-16 NR mobility measurement, reuse it for CSI-RS L3 measurement.
	+ Option 4: Not needed.
* Recommended WF
	+ According to the majority views, option 2 can be removed firstly.
	+ If agreed to introduce UE capability, LS to RAN2 is needed

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| **Issue 2-4-1: Whether to introduce UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell** |
| **Company** | **Comments** |
| vivo | We prefer option 1. |
| MTK | Support Option 1. It is dangerous to extend other R15/R16 UE capability. However, if this is a scenario that can be avoided by network, we also prefer to have no requirement without any UE capability. |
| CATT | Support option 1 |
| Intel | prefer option 1. |
| ZTE | It may not be typical case that CSI-RS of neighbor cell collides with SSB of serving cell because usually SSBs of serving cell and neighbor cell are collided. |
| Huawei | option 1 or option 4 is fine to us. |
| Nokia, Nokia Shanghai Bell | We agree with Option1. |
| Qualcomm | We donot have a strong opinion on this issue between option 1 and option4.Recommended WF is ok for further agreements. |
| Apple | Option 1 |
| OPPO | Agree with the recommended WF. |
| Docomo | We have no idea about whether this case occurs frequently or not. If this is rare case, we prefer Option 4. Otherwise, Option 1 is fine. |

### Sub-topic 2-5: Scheduling Restriction

*Sub-topic description*

* The requirements for scheduling restriction are only defined for CSI-RS L3 measurement without gaps
* Identify all possible factors which would cause scheduling restriction in next meeting:
	+ Collision with UL transmission and DL measurement on TDD carrier
	+ The need of Rx beam sweeping in FR2
	+ Mix-numerology between data/SSB of serving cell and CSI-RS of neighbour cell

*Open issues and candidate options before e-meeting:*

**Issue 2-5-1: Scheduling restriction if UE is not able to support mixed numerology of data and CSI-RS L3 mobility**

* Proposals
	+ Option 1: If UE is not able to support mixed numerology of data and CSI-RS L3 mobility, the following scheduling restrictions apply due to intra-frequency CSI-RS based L3 measurement:
		- if the associatedSSB is configured, UE is not expected to transmit or receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.
		- if the associatedSSB is not configured, no requirements apply.
* Recommended WF
	+ Option 1

**Issue 2-5-2: Scheduling restriction when UE performs CSI-RS intra-frequency measurements in a TDD band**

* Proposals
	+ Option 1:
		- When UE performs CSI-RS intra-frequency measurements in a TDD band, UE is not expected to transmit and receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured.
	+ Option 2:
		- The scheduling restriction on additional OFDM symbols before and after SSB is not needed.
			* Based on the assumption that the FFT window timing always follows the serving cell timing for intra frequency measurement and is up to UE implementation for inter frequency measurement.
* Recommended WF
	+ FFS.

**Issue 2-5-3: Whether to consider scheduling restriction when UE performs RX beam sweeping**

* Proposals
	+ Option 1: yes
		- Option 1a: Define scheduling restriction on one data symbol before and after CSI-RS symbol to be measured due to Rx beam sweeping.
	+ Option 2: No
* Recommended WF
	+ FFS.

**Issue 2-5-4: Collision between L1 measurement of serving cell and CSI-RS L3 measurement of neighbour cell**

* Proposal:
	+ Option 1: Do not define CSI-RS measurement requirements for the collision case.
	+ Option 2: Network should configure L1 measurement resource to avoid collision with CSI-RS L3 measurement resource of neighbour cell.
* Recommended WF
	+ FFS

**Issue 2-5-5: Scheduling restriction if the timing difference between serving and neighbor cell including cell phase synchronization is guaranteed to be less than CP length**

* Proposal:
	+ Option 1: No requirements
* Recommended WF
	+ Option 1
	+ Issues related to synchronization should be discussed in email thread [225]

**Issue 2-5-6: Others for no scheduling restriction**

* Proposal:
	+ Option 1: If UE can perform CSI-RS based measurement independently with SSB based measurement, no scheduling restriction shall be configured.(Huawei)
* Recommended WF
	+ FFS

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| **Issue 2-5-1: Scheduling restriction if UE is not able to support mixed numerology of data and CSI-RS L3 mobility** |
| **Company** | **Comments** |
| vivo | Support the recommended WF. |
| MTK | We do not understand why 2 DL data OFDM symbols needs to be considered here if CSI-RS only occupies 1 DL OFDM symbol.**Response to Huawei**: We do not share the same view on how UE decide the FFT window for intra-frequency neighboring cell measurement, even if the scheduling restriction allows UE to skip the data reception from serving cell. The point here is that UE may need to measure multiple CSI-RS coming at the same OFDM symbol, e.g., UE may also need to measure CSI-RS from its serving cell and other neighboring cell at the same time. In that case, we believe that the best FFT timing is still based on UE’s serving cell. Anyway, it seems we need to first conclude the sync assumption in [225] before working on scheduling restriction requirement. |
| ZTE | Same view as MTK. |
| Huawei | Agree with the recommended WF.To MTK: If the *associatedSSB* is configured, UE performs CSI-RS measurement based on the timing of the target cell which can be misaligned with the serving cell timing. Then UE is not expected to transmit or receive on 2 data OFDM symbols impacted by CSI-RS resource symbol to be measured. |
| Nokia, Nokia Shanghai Bell | We are fine with the principle of the proposals. But would like to leave “2” data OFDM symbols open for further study.  |
| Qualcomm | We wonder how to determine the extra symbol. Should we consider 3symbols instead? That is, one extra symbol before and after the “Impacted symbol”.Does enablement of the restriction depend on the UE capability to do simultaneous serving data and neighbor CSI-RS?  |
| Apple | In Huawei’s example, sometimes 3 data symbols can be impacted. Some further revision is needed. When 33us MRTD is considered for inter-band CA, scheduling restriction can be large. Further study is needed. |
| OPPO | Agree with Nokia. To move a bit forward, we can leave [2] in square bracket for further study. |
| Docomo | We have similar view as MTK. Whether 2 data OFDM symbols are really needed to be restricted or not needs more discussion, and we should conclude the discussion of synchronization assumption in [225] firstly. |

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| **Issue 2-5-2: Scheduling restriction when UE performs CSI-RS intra-frequency measurements in a TDD band** |
| **Company** | **Comments** |
| vivo | For intra-frequency measurement, single FFT window is assumed. However, we are also fine to introduce such scheduling restriction, which means UE is allowed to track window of the strongest cell in CSI-RS based RRM requirement.Therefore, we support option 1. |
| MTK | Question for clarification. The additional 1 data OFDM symbol is to address the TA uncertainty, right? |
| ZTE | FFS |
| Huawei | Support option 1.To MTK, the additional 1 data OFDM symbol comes from the timing difference between target cell and serving cell. |
| Nokia, Nokia Shanghai Bell | The scheduling restriction depends on the timing difference between serving and neighbor cells. As this is under discussion, we can come back to it when the timing issue is concluded.  |
| Qualcomm | FFS |
| Apple | FFS. Misalignment in TDD can be as large as max(2SSB symbols, 1PDSCH symbol). We should consider this in scheduling restriction.  |
| OPPO | FFS |
| Docomo | Option 2. In TDD bands, we think precise timing synchronization is essential, thus any additional restriction on OFDM symbols before and after SSB is not needed. |

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| **Issue 2-5-3: Whether to consider scheduling restriction when UE performs RX beam sweeping** |
| **Company** | **Comments** |
| vivo | Fine to option 1 since synchronization assumption may differ due to RX beam sweeping. |
| MTK | Yes. But whether to allow 1 additional OFDM symbol with scheduling restriction needs some further discussion. |
| ZTE | FFS |
| Huawei | Support option 1. |
| Nokia, Nokia Shanghai Bell | Why 1 additional OFDM symbol is concerned due to Rx beam sweeping?  |
| LG | We prefer option 1 since one data symbol before and after CSI-RS symbol to be measured can be affected as described in our contribution R4-2006841. |
| Qualcomm | FFS. First companies need to agree if requirements shall be defined when CSI-RS is not QCLed to its associated SSB. |
| Apple | Agree with Qualcomm |
| Docomo | In the previous meeting, it was agreed that requirements will be defined when CSI-RS is configured with an associated SSB. Taking this into account, the UE will not need Rx beam sweeping because the *associatedSSB* is assumed to be configured and the UE could try Rx beam based on SSB indicated by *associatedSSB* before measurement. Thus, there is no necessity to consider scheduling restriction, so we prefer option 2. |

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| **Issue 2-5-4: Collision between L1 measurement of serving cell and CSI-RS L3 measurement of neighbour cell**  |
| **Company** | **Comments** |
| vivo | Fine to option 1. RAN4 do not specify requirement for L1-RSRP if CSI-RS measurement collides with L1-RSRP. |
| MTK | Both Option 1 and Option 2 are fine to us. Note that the collision could be across CCs for intra-band FR2 CA because UE can only for either rough beam or fine beam at a time. |
| ZTE | FFS |
| Huawei | Option 1 |
| Nokia, Nokia Shanghai Bell | This needs to be solved. Further discussion is expected.  |
| LG | We prefer option2. Note that CSI-RS L3 measurement is optional feature and UEs measure CSI-RS resource only when there is a network configuration. Therefore, the collision between L1 measurement of serving cell and L3 measurement of neighbour cell can be avoided by the network configuration. |
| Qualcomm | Shall we please clarify if the L1 measurements refer to SSB and/or CSI-RS? In general option 2 is preferred. For example, both serving cell CSI-RS and L3 CSI-RS of neighbor cells are known configurations to the network. So collision should be avoidable. For another, SSB mostly doesnot share the searcher with CSI-RS. |
| Apple | Suggest postpone this to R17 |
| OPPO | We are fine with either option 1 or 2. |
| Docomo | FFS |

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| **Issue 2-5-5: Scheduling restriction if the timing difference between serving and neighbor cell including cell phase synchronization is guaranteed to be less than CP length** |
| **Company** | **Comments** |
| MTK | Pending on the conclusion of other discussion |
| ZTE | Pending on the conclusion of other discussion |
| Huawei | Come back after synchronization discussion had conclusion |
| Nokia, Nokia Shanghai Bell | The scheduling restriction depends on the timing difference between serving and neighbor cells. As this is under discussion, we can come back to it when the timing issue is concluded.  |
| LG | We prefer option 1. |
| Qualcomm | Agree with companies to hold. |
| Apple | Not clear how to capture and guarantee the time different assumption |
| OPPO | FFS |
| Docomo | Support Huawei’s opinion. We should discuss synchronization assumption firstly. |

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| **Issue 2-5-6: Others for no scheduling restriction** |
| **Company** | **Comments** |
| XXXvivo | Fine to option 1. |
| MTK | Option 1 seems to miss some details, e.g., whether the SCS is the same and whether the SSB is to be used for L1 measurements.  |
| ZTE | The question is not clear. |
| Huawei | Option 1 is not clear. |
| Nokia, Nokia Shanghai | What does “independently” mean? Would be good to clarify the question here.  |
| Qualcomm | Assume option1 refers to intra-frequency CSI-RS and intra-frequency SSB, then it’s agreed that no scheduling restriction is needed. An exception is they require using different Rx beams in FR2, in which case, agreements are not yet reached. We would also suggest more clarifications on this issue. |
| Apple | Pending on other discussion. |
| OPPO | As option 1 is proposed by Huawei (R4-2007736) who also thinks option 1 is not clear, we suggest to remove this issue and no more discussion is expected. |
| Docomo | The meaning of “independently” is vague. |

## Companies views’ collection for 1st round

### Open issues

Moderator: please comment directly in the tables under the text of corresponding issues in clause 2.2.

* Sub-topic 2-1: General
* Sub-topic 2-2: Measurement delay
* Sub-topic 2-3: Scaling Factor
* Sub-topic 2-4: UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell
* Sub-topic 2-5: Scheduling Restriction

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

Moderator: How to handle and split CRs will be covered in 1st round summary of email thread [225]. No discussion is expected here.

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| **CR/TP number** | **Comments collection** |
| [**R4-2006228**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006228.zip) | Company A |
| Company B |
|  |
| [**R4-2006229**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006229.zip) | Company A |
|  | Company B |
|  |  |
| [**R4-2006230**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2006230.zip) | Company A |
|  | Company B |
|  |  |
| [**R4-2007357**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007357.zip) | Company A |
|  | Company B |
|  |  |
| [**R4-2007358**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007358.zip) | Company A |
|  | Company B |
|  |  |
| [**R4-2007359**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007359.zip) | Company A |
|  | Company B |
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| [**R4-2007360**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007360.zip) | Company A |
|  | Company B |
|  |  |
| [**R4-2007739**](http://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_95_e/Docs/R4-2007739.zip) | Company A |
|  | Company B |
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## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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|  | **Status summary**  |
| **Sub-topic#2-1** | **Issue 2-1-1: Whether to define requirements related to associated SSB***Tentative agreements:*No requirements shall be defined in Rel-16 for CSI-RS L3 measurement, when1. associated SSB is not configured
2. associated SSB is not detected even if associated SSB is configured

*Candidate options:**Bullet - 3):* * + - *No: 5 companies,*
		- *Yes: 7 companies including 2 companies supporting especially for FR2*

*Bullet - 4):* * + - *FFS: 8 companies.*
		- *No: 2 companies*

*Bullet - 5):** + - *No: 2 companies,*
		- *Yes: 7 companies*

*Recommendations for 2nd round:*Continue discussion on 3) and 5). No more discussion on 4). And compromises from companies are expected on 5).* + No requirements shall be defined in Rel-16 for CSI-RS L3 measurement, when
1. associated SSB is not QCLed with CSI-RS
2. ~~associated SSB is configured and detected but the corresponding target cell timing has a large delta from the UE’s serving cell timing.~~
3. associated SSB is not included in ssb-ToMeasure in SSB-ConfigMobility in the same MO.

**Issue 2-1-2: Whether to define requirements related to the serving CSI-RS resource and MO configuration***Tentative agreements:*Follow the agreement in Email thread [225]**Issue 2-1-3: Conditions for gap-needed or gapless***Tentative agreements:* Define requirements only for intra-f without gap and inter-f with gap in Rel-16.* Option 1:
	+ All inter-frequency measurements are gap-assisted.
	+ All intra-frequency measurements are gapless.
 |
| **Sub-topic#2-2** | **Issue 2-2-1: Cell identification time***Tentative agreements:** For CSI-RS intra-frequency measurement, cell identification time can be expressed as follows:
	+ TCSI-RS\_identify\_intra= (TPSS/SSS\_sync\_intra + T CSI-RS\_measurement\_period\_intra + TSSB\_time\_index\_intra) ms
	+ FFS: whether to introduce 2 different requirements for with index and without index.
* The CSI-RS based intra-frequency cell identification comprises SSB-based cell identification and CSI-RS based measurements, where SSB-based cell identification is the same as the intra-frequency cell identification for SSB-based measurement.
	+ TPSS/SSS\_sync\_intra and TSSB\_time\_index\_intra can be reused for the case that cell search via SSB and PBCH decoding are needed.
* FFS inter-frequency CSI-RS measurement.
* If UE already detects the SSB of the target cell and deriveSSB-IndexFromCell is indicated, UE can skip PBCH decoding.

*Candidate options:** + Option 1: 5 companies
	+ Option 3: 3 companies
	+ Option 2 and 4 can be merged.

*Recommendations for 2nd round:*Continue discussion.* + **FFS** TCSI-RS\_identify\_intra\_without\_index
	+ **FFS** inter-frequency CSI-RS measurement.
		- Alt1: the framework for intra-f can be reused
		- Alt2: for inter-frequency CSI-RS measurement (from option 3)
* For FR1 FDD, UE needs to perform PSS/SSS detection, DMRS matching and PBCH decoding and inter-frequency CSI-RS measurement.
* For FR1 TDD and FR2, UE shall perform PSS/SSS detection, PBCH decoding and inter-frequency CSI-RS measurement.
	+ - **FFS** AGC adjustment time shall be considered when UE needs to retune RF to an inter-frequency layer to perform measurement.

**Issue 2-2-2: CSI-RS measurement period***Tentative agreements:*Reuse SSB samples for intra-frequency and inter-frequency CSI-RS L3 measurements period.* FFS: the measurement accuracy of CSI-RS is no worse than the measurement accuracy of SSB measurement

*Candidate options:** + Option 1: 9 companies
	+ Option 2: 1 companies
	+ Option 3: 2 companies

*Recommendations for 2nd round:*Compromises are expected from companies. More discussion is expected on assumption on measurement accuracy of CSI-RS.**Issue 2-2-3: the tuning time for CSI-RS based measurements***Tentative agreements:* None.*Candidate options:** + *Option 1: The tuning time shall be longer than the gap switch time for measuring the inter-frequency SSBs.*
	+ *Option 2: The tuning time of inter-frequency GAP of CSI-RS measurement shall be equal to the gap switch time for measuring the inter-frequency SSBs.*
	+ *Option 3: Defined as a UE capability.*

*Recommendations for 2nd round:*Need more discussion.  |
| **Sub-topic#2-3** | **Issue 2-3-1: Whether dedicated searcher(s) is assumed for CSI-RS based measurement?***Tentative agreements:* None *Candidate options:** + Option 1: 4 companies
	+ Option 2: 2 companies

*Recommendations for 2nd round:*Continue discussion, and **FFS** the relation of dedicated search and CSSF.**Issue 2-3-2: CSSF requirements***Tentative agreements:*Pending on the conclusion on time-domain restriction. Need more discussion.**Issue 2-3-3: Scaling factor N for RX beam sweeping***Tentative agreements:*Do not define requirements when associated SSB is not QCLed with CSI-RS in Rel-16*Candidate options:** + Option 1: 1 company
	+ Option 2: 4 companies
	+ Option 3: 5 companies

*Recommendations for 2nd round:* Need more discussion. It can be discussed together with **Issue 2-1-1.****Issue 2-3-4: RX beam sweeping when CSI-RS is QCL-ed to the associated SSB***Tentative agreements:* Keep the last agreement no Rx sweeping is needed*Candidate options:** + Option 1: 9 companies
	+ Option 2: 2 companies

*Recommendations for 2nd round:* * FFS the case that the multiple CSI-RS resources from different cells are transmitted in the same OFDM symbols in one MO, and the CSI-RS resources are QCL-ed with different associated SSB.
 |
| **Sub-topic#2-4** | **Issue 2-4-1: Whether to introduce UE capability to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell***Tentative agreements:*FFS: Introduce **new UE capability** to indicate the simultaneous reception of CSI-RS of neighbour cell and SSB of serving cell *Candidate options:** + Option 1 (New UE capability): 9 companies
	+ Option 4 (No): 4 companies

*Recommendations for 2nd round:*Continue discussion. If agreed to introduce UE capability, **an LS** should be sent out to RAN2 in this meeting. |
| **Sub-topic#2-5** | **Issue 2-5-1: Scheduling restriction if UE is not able to support mixed numerology of data and CSI-RS L3 mobility***Tentative agreements:* UE is not expected to transmit or receive on [TBD] data OFDM symbols impacted by CSI-RS resource symbol to be measured. *Candidate options:** + Option 1: 4 companies
	+ FFS: 5 companies

*Recommendations for 2nd round:*Continue discussion. FFS [2] data OFDM symbols.**Issue 2-5-2: Scheduling restriction when UE performs CSI-RS intra-frequency measurements in a TDD band***Tentative agreements: None**Candidate options:** + Option 1: 2 companies
	+ Option 2: 1 companies
	+ FFS: 4 companies

*Recommendations for 2nd round:*Continue discussion.**Issue 2-5-3: Whether to consider scheduling restriction when UE performs RX beam sweeping***Tentative agreements: None**Candidate options:** + Option 1: yes, 4 companies
	+ Option 2: No, 1 companies
	+ FFS : 4 companies

*Recommendations for 2nd round:*Continue discussion.**Issue 2-5-4: Collision between L1 measurement of serving cell and CSI-RS L3 measurement of neighbour cell** *Tentative agreements: None**Candidate options:** + Option 1: 3 companies
	+ Option 2: 4 companies
	+ FFS: 4 companies.

*Recommendations for 2nd round:*Continue discussion.**Issue 2-5-5: Scheduling restriction if the timing difference between serving and neighbor cell including cell phase synchronization is guaranteed to be less than CP length***Tentative agreements:* Come back to it when the issue **synchronization assumption** is concluded.**Issue 2-5-6: Others***Tentative agreements: None**Candidate options:** + Option 1: If UE can perform CSI-RS based measurement independently with SSB based measurement, no scheduling restriction shall be configured.(Huawei)

*Recommendations for 2nd round:**This issues is going to be removed and no more discussion in this meeting.* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 | WF on CSI-RS based L3 measurement capability and requirements | OPPO |
| #2 | LS on UE capability of simultaneous reception of CSI-RS of neighbor cell and SSB of serving cell*(Moderator: Whether LS is needed depends on the conclusion of Issue 2-4-1)* | OPPO |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |