**3GPP TSG-RAN WG4 Meeting #94-e R4-20xxxxx**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 8.16.1 & 8.16.1.1 & 8.16.1.2 & 8.16.1.6

**Source:** CATT

**Title:** Email discussion summary for RAN4#94e\_#65\_NR\_CSIRS\_L3meas\_RRM\_Part\_1

**Document for:** Information

# Introduction

The documents in agenda items 8.16.1.1 & 8.16.1.2 & 8.16.1.6 contain the following 3 main topics:

* Topic #1: CSI-RS measurement configuration (AI 8.16.1.1)
* Topic #2: Intra-frequency and inter-frequency measurement definition (AI 8.16.1.2)
* Topic #3: Others (AI 8.16.1.6)

# Topic #1: CSI-RS measurement configuration (AI 8.16.1.1)

## 2.1 Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000386 | Intel | **Proposal 1:** Define requirement for one configuration with 48PRBs and D = 3. |
| R4-2000462 | MediaTek | **Observation 1:** Larger measurement BW does not always lead to better measurement accuracy requirement because the RF path loss calibration error also increases.  **Proposal 1:** Requirement is defined based on single measurement bandwidth (N=1).  **Proposal 2:** For CSI-RS based L3 measurement, the requirements are specified based on 48 PRBs and density 3. |
| R4-2000582 | CATT | **Observation 1:** It was observed that 5 samples of measurement can achieve the acceptable accuracy requirement when CSI-RS configuration is configured with {PRB=48 and D=1}.  **Observation 2:** It was observed that 3 samples of measurement can achieve the acceptable accuracy requirement when CSI-RS configuration is configured with {PRB=48 and D=3} or {PRB=96 and D=1}.  **Proposal:** 2 set of CSI-RS based measurement requirements shall be defined based on the combination of measurement bandwidth of CSI-RS and CSI-RS resource density, which is expressed in Table 1.  Table 1: TCSI-RS\_measurement\_Period with different configurations   |  |  |  |  | | --- | --- | --- | --- | | Configuration | Measurement bandwidth [RB] | CSI-RS resource Density | TCSI-RS\_measurement\_Period | | 0 | 48 | 1 | 5 samples | | 1 |  | 3 | 3 samples | |
| R4-2000636 | CMCC | ***Proposal 1:*** *it is proposed to define CSI-RS based measurement requirements for two sets of configurations.*  ***Proposal 2:*** *it is proposed to separate requirements based on the number of CSI-RS REs.*  ***Proposal 3:*** *it is proposed to specify CSI-RS based measurement requirements based on 48REs and 192 REs.*   |  |  | | --- | --- | | *The configuration based on which requirements are specified* | *The case that the requirements are applied to* | | *48REs (48 RB, density = 1)* | *the case with number of CSI-RS RE <192, including 24RB with D=3, 48RB with D=1, 96RB with D=1* | | *192REs (192 RB, density = 1)* | *the case with number of CSI-RS RE >=192, including 96RB with D=3, 192RB with D=1, 192RB with D=3, 264RB with D=1, 264RB with D=3* | |
| R4-2000655 | Nokia, Nokia Shanghai Bell | **Proposal1:** 48PRB and Density = 1 is applied for defining the CSI-RS based measurement requirements.  **Proposal2:** Do not define the measurement requirements for 24 PRBs.  **Proposal3:** Define additional CSI-RS measurement requirements for 96 PRBs, 192 PRBs and 264 PRBs.  **Proposal4:** The measurement requirements for wider bandwidth can be defined with one of the options below:   * Option1: Define better accuracy assuming same number of samples. * Option2: Keep accuracy requirements same assuming measuring in WB and samples.   **Proposal5:** The UE may apply the measurement requirement as one of the options, if the configured measurement bandwidth is partially overlapping with the active BWPs:   * Option1: Define reduced accuracy requirements assuming available CSI-RS resources within the active BWP. * Option2: Keep accuracy requirement assuming longer measurement evaluation time (i.e. increased measurement samples). * Option3: Keep same accuracy but UE has to measure more often (if possible - hence if RS is available) |
| R4-2000655 | Nokia, Nokia Shanghai Bell | Simulation results for CSI-RS based measurements. |
| R4-2000655 | NTT DOCOMO, INC. | **Observation:** The number of PRBs for CSI-RS is greatly different compared to that of SSB (127 REs for SSS).  **Proposal 1:** Core requirements for CSI-RS-based L3 measurements should be able to cover various CSI-RS configurations.  **Proposal 2:** For CSI-RS based L3 measurement, two patterns of configuration sets should be adopted as below under the same delay requirement.   * Number of PRBs ≧24, Density = 3 * Number of PRBs ≧96, Density = 1 |
| R4-2000655 | Huawei, HiSilicon | ***Proposal 1:*** *For L3 mobility, RAN4 defines CSI-RS based measurement requirements provided that the bandwidth of CSI-RS is 48 PRBs and the density is 3.*  ***Proposal 2:*** *The CSI-RS based measurement period for L3 mobility can be defined as 5 measurement samples.* |

## 2.2 Open issues summary

Agreements on CSI-RS configuration agreed in R4-1913749 in RAN4#93 meeting:

* CSI-RS configurations (bandwidth of CSI-RS and density of CSI-RS resource) used to define requirements
* Define requirements at least for 1 set of configurations
  + Option 1: 48PRBs and D = 1
  + Option 2: 48PRBs and D = 3
* FFS whether to define requirements for additional configurations
  + 48PRBs and D = 1
  + 48PRBs and D = 3
  + 96PRBs and D = 1
  + 96PRBs and D = 3

### 2.2.1 CSI-RS measurement configuration

*Sub-topic description:*

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

**Issue 1-1: How many set of CSI-RS configuration (bandwidth of CSI-RS and density of CSI-RS resource) are needed to define CSI-RS based measurement requirements?**

* Option 1: 1 set of configuration (Intel, MediaTek, Huawei )
* Option 2: 2 set of configuration (CATT, CMCC, NTT DOCOMO)
* Option 3: Multiple set of configuration (Nokia)
* Recommended WF
  + Need more discussion

**Issue 1-2: If one set of configuration is agreed, what’s the configuration for bandwidth of CSI-RS and density of CSI-RS resource?**

* Option : 48PRBs and D = 3 (Intel, MediaTek, Huawei )

**Issue 1-3: If two sets of configuration is agreed, what’s the configuration for bandwidth of CSI-RS and density of CSI-RS resource?**

* Option 1: (CATT )

|  |  |  |  |
| --- | --- | --- | --- |
| Configuration | Measurement bandwidth [RB] | CSI-RS resource Density | TCSI-RS\_measurement\_Period |
| 0 | 48 | 1 | 5 samples |
| 1 |  | 3 | 3 samples |

* Option 2: Separate requirements based on the number of CSI-RS REs (CMCC)

|  |  |
| --- | --- |
| The configuration based on which requirements are specified | The case that the requirements are applied to |
| 48REs (48 RB, density = 1) | the case with number of CSI-RS RE <192, including 24RB with D=3, 48RB with D=1, 96RB with D=1 |
| 192REs (192 RB, density = 1) | the case with number of CSI-RS RE >=192, including 96RB with D=3, 192RB with D=1, 192RB with D=3, 264RB with D=1, 264RB with D=3 |

* Option 3: (NTT DOCOMO)
  + Two patterns of configuration sets should be adopted as below under the same delay requirement.
    - Number of PRBs ≧24, Density = 3
    - Number of PRBs ≧96, Density = 1
* Recommended WF
  + Need more discussion

**Issue 1-4: If multiple sets of configuration is agreed, what’s the configuration for bandwidth of CSI-RS and density of CSI-RS resource?**

* Option : (Nokia )
  + 48PRB and Density = 1 is applied for defining the CSI-RS based measurement requirements.
  + Define additional CSI-RS measurement requirements for 96 PRBs, 192 PRBs and 264 PRBs.
* Recommended WF
  + Need more discussion

## 2.3 Companies views’ collection for 1st round

### 2.3.1 Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Issue 1-1:  Considering that better measurement performance is expected when larger BW or density is configured, we still prefer to define 2 sets of requirements.  Issue 1-3:  Our consideration is to sperate the requirements based on the number of CSI-RS REs. But we are open to have discussion on how to separate the requirements.  Sub topic 1-2:  ….  Others: |
| ZTE | Issue 1-1: We support to have 2 set of requirements.  Issue 1-3: We support option 1. This is similar to traditional ways in LTE of defining CSI-RS measurement requirements that different bandwidth/density of CSI-RS resource will lead to different measurement delay. |
| CATT | Issue 1-1: Support to define 2 set of requirements  Different of CSI-RS configuration can have different delay requirement, thus we prefer to have one set of legacy requirement and one set of enhancement requirement. And two set of configuration can also reflect the flexibility of CSI-RS measurement from RRM point of view.  Issue 1-1: support option 1. One is for legacy requirements which 5 measurement samples are needed to define the measurement delay requirement, and the other is for enhancement requirements which 3 measurement are required to define the requirement. |
| Huawei, HiSilicon | Issue 1-1:  We propose option 1 to define 1 set of CSI-RS measurement requirements.  In LTE, CRS bandwidth is same as system bandwidth and can be configured from 6RBs to 100RBs. UE is assumed to perform RSRP measurement on central 6 RBs. The RSRP measurement accuracy requirements are defined based on 6RBs.  Issue 1-2:  We propose to define the CSI-RS measurement requirements with 48RBs and density=3. |
| Nokia, Nokia Shanghai Bell | Issue 1-1: We support to define multiple requirements for different bandwidths.  As the network may configure different measurement bandwidths, the minimum performance is expected from the network per configurable bandwidth. Single requirement is not enough.  Issue 1-4: The requirements could be per configurable bandwidth. Both D=1 and D=3 shall be considered. |
| MTK | **Issue 1-1**:  Support option 1.  BTW, we suggest to first conclude on Issue 1-3 before we touch Issue 1-1. Otherwise, companies supporting Option 2 of Issue 1-1 are actually not on the same page, if different companies prefers different alternatives in Issue 1-3.  **Issue 1-2**:  This seems the only option on the table if N=1. We suggest to make a conditional agreement that if N=1, then the configuration is 48 PRBs with D=3. |
| Apple | **Issue 1-1**: Option 1. Motivation to define more than 1 set of requirements is not very clear. Considering RAN4 only specifies the minimum requirements, we should leave it as UE implementation for better performance.  Issue 1-2: if there is single set configuration, shouldn’t we consider the worse case, e.g. D=1? Otherwise, it will prevent NW from configuring 48PRB with D=1 since the related UE performance cannot be guaranteed, unless simulations suggest this configuration cannot work.  Issue 1-3: depend on the conclusion of Issue 1-1 |
| QC | Issue 1-1: How many set of CSI-RS configuration (bandwidth of CSI-RS and density of CSI-RS resource) are needed to define CSI-RS based measurement requirements?  Agree with option 1. There is no real justification to define requirements for more than one set.  Issue 1-2: If one set of configuration is agreed, what’s the configuration for bandwidth of CSI-RS and density of CSI-RS resource?  Agree with option 1. This has the added advantage of retaining consistency with configuration defined for RLM/BFR |
| Ericsson | Issue 1-1: support option 3 but could compromise to option 2  Issue 1-3: option 1 or option 3. |
| DOCOMO | Issue 1-1: CSI-RS for L3 measurement can be applied with different configurations with respect to the # of PRBs and density. We should have core requirements that can cover these different parameters. Therefore, we should have multiple candidates in terms of the PRBs and the density. Thus, we think multiple sets (option 2 or 3) of configuration are beneficial.  Issue 1-3,1-4: As summarized in table 2 in our contribution, for the core requirements for RLM, BFD and CBD, the number of PRBs and density are 24>= and 3, respectively. It is straightforward to reuse the values for CSI-RS-based L3 measurements. Considering that the number of REs, (PRB, density)=(96>=, 1) should be able to be covered in the requirements. Thus, we propose to cover following CSI-RS configurations in the core requirements.   * Number of PRBs ≧24, Density = 3 * Number of PRBs ≧96, Density = 1   Possible grouping can be FFS. |
| Intel | Sub topic 1-1: propose to define one configuration where 48RB and D=3. |

### 2.3.2 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.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## 2.4 Summary for 1st round

### 2.4.1 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.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Issue 1-1:**  How many set of CSI-RS configuration (bandwidth of CSI-RS and density of CSI-RS resource) are needed to define CSI-RS based measurement requirements | *Tentative agreements: further discussion is needed*  *Candidate options:*   * *Option 1: 1 set of configuration (Intel, MediaTek, Huawei, Apple, Qualcomm )* * *Option 2: 2 set of configuration (CATT, CMCC, NTT DOCOMO, ZTE, Ericsson)* * *Option 3: Multiple set of configuration (Nokia, Ericsson)*   *Recommendations for 2nd round: Can proponents of option 2 and option 3 accept one unified requirement?* |
| **Issue 1-2:**  If one set of configuration is agreed, what’s the configuration for bandwidth of CSI-RS and density of CSI-RS resource? | *Tentative agreements: 48PRBs and D = 3 if option 1 for issue 1-1 is agreed*  *Recommendations for 2nd round: further discuss other applicable CSI-RS configuration for one set of requirement.*  *Candidate options:*  *Option 1: D=3 with PRBs ≧48*  *Option 2: D=3 with PRBs ≧48 and D=1 with PRBs ≧96* |
| **Issue 1-3:**  If two sets of configuration is agreed, what’s the configuration for bandwidth of CSI-RS and density of CSI-RS resource? | *Tentative agreements: more discussion is needed for CSI-RS configuration.*  *Recommendations for 2nd round:*  *Candidate options:*   * Option 1: (CATT, ZTE, Ericsson )  |  |  |  |  | | --- | --- | --- | --- | | Configuration | Measurement bandwidth [RB] | CSI-RS resource Density | TCSI-RS\_measurement\_Period | | 0 | 48 | 1 | 5 samples | | 1 |  | 3 | 3 samples |  * Option 2: Separate requirements based on the number of CSI-RS REs (CMCC)  |  |  | | --- | --- | | The configuration based on which requirements are specified | The case that the requirements are applied to | | 48REs (48 RB, density = 1) | the case with number of CSI-RS RE <192, including 24RB with D=3, 48RB with D=1, 96RB with D=1 | | 192REs (192 RB, density = 1) | the case with number of CSI-RS RE >=192, including 96RB with D=3, 192RB with D=1, 192RB with D=3, 264RB with D=1, 264RB with D=3 |  * Option 3: (NTT DOCOMO, Ericsson)   + Two patterns of configuration sets should be adopted as below under the same delay requirement.     - Number of PRBs ≧24, Density = 3     - Number of PRBs ≧96, Density = 1 |
| **Issue 1-4:**  If multiple sets of configuration is agreed, what’s the configuration for bandwidth of CSI-RS and density of CSI-RS resource? | *Tentative agreements: more discussion is needed for CSI-RS configuration.*  *Recommendations for 2nd round:*  *Candidate options:*  *Define multiple set of requirement (Nokia)*  *Discuss the requirements for configurable bandwidth. Both D=1 and D=3 shall be considered.* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### 2.4.2 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”* |

## 2.5 Discussion on 2nd round (if applicable)

### 2.5.1 CSI-RS measurement configuration

1st round email discussion conclusions

Session chair: The RAN4 #93 agreements are as follows

* *Define requirements at least for 1 set of configurations*
  + *Option 1: 48PRBs and D = 1*
  + *Option 2: 48PRBs and D = 3*
* *FFS whether to define requirements for additional configurations*
  + *48PRBs and D = 1*
  + *48PRBs and D = 3*
  + *96PRBs and D = 1*
  + *96PRBs and D = 3*

Based on current email summary status there is no consensus to introduce additional configurations.

For the 2nd round discuss Issue 1-2 (down-selection between Option 1 and Option 2 for 1 set of configurations). Discussion on additional configurations (>1) can continue in RAN4 #94bis.

**Issue 1-1: Applicable CSI-RS configuration for one set of requirement**

* + *Option 1: 48PRBs and D = 1*
  + *Option 2: 48PRBs and D = 3*
* *Recommendations for 2nd round:*

*Moderator suggests companies to provide comments on above candidate options. And possible compromises to move forward are welcome.*

**Issue 1-2: Additional CSI-RS configurations (>1) for additional set of requirements**

* + *Option 1: 48PRBs and D = 1*
  + *Option 2:*

|  |  |
| --- | --- |
| *The configuration based on which requirements are specified* | *The case that the requirements are applied to* |
| *48REs (48 RB, density = 1)* | *the case with number of CSI-RS RE <192, including 24RB with D=3, 48RB with D=1, 96RB with D=1* |
| *192REs (192 RB, density = 1)* | *the case with number of CSI-RS RE >=192, including 96RB with D=3, 192RB with D=1, 192RB with D=3, 264RB with D=1, 264RB with D=3* |

* + *Option 3: Two patterns of configuration sets should be adopted as below under the same delay requirement.*
    - *Number of PRBs ≧24, Density = 3*
    - *Number of PRBs ≧96, Density = 1*
  + *Option 4:* *Define additional CSI-RS measurement requirements for 96 PRBs, 192 PRBs and 264 PRBs.*
  + *Option 5: No extra set of requirements*
* *Recommendations for 2nd round:*

*Moderator suggests companies to provide comments on above candidate options. And possible compromises to move forward are welcome.*

### 2.5.2 Companies views’ collection for 2nd round

**Issue 1-1: Applicable CSI-RS configuration for one set of requirement**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | We had this discussion during RLM and CBD/BFR too. With D=1 the performance was found to be lacking especially in fading channels. Thus we support Option 2. Need clarification from proponents of option 1 as to why the performance is acceptable here when it wasn’t in RLM and CBD. |
| CATT | According to the simulation results, for {PRB =96, D=1} and {PRB = 192, D=1}, the current accuracy requirement is fulfilled.  We can accept one set of requirement as a compromise. But for the CSI-RS configuration, we propose one set of requirement can apply to the following case:   * *D=3 with PRBs ≧48* * *D=1 with PRBs ≧96* |
| CMCC | We prefer to define two sets of requirements, to move forward, we can accept CATT’s suggestion as a compromise. Or the other option is that the requirements applied condition is provided in the number of REs. For example, requirements can apply to the case with CSI-RS REs >= 96. Both are OK for us. |
| Huawei, HiSilicon | We support option 2 “48PRBs and D = 3”  We share the same concern on the CSI-RS measurement performance with D=1. |

**Issue 1-2: Additional CSI-RS configurations (>1) for additional set of requirements**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | The option for defining no extra set of requirements is missing. We would want to define only one set of requirements. Added opition 5 above. |

## 2.6 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”* |

# 3 Topic #2: Intra-frequency and inter-frequency measurement definition (AI 8.16.1.2)

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

## 3.1 Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000387 | Intel | **Observation 1:** The definition of positioning frequency layer is defined as:   |  | | --- | | * the same SCS and CP type * the same centre frequency * the same point-A * the same value of DL PRS Bandwidth and Start PRB |   **Proposal 1:** Similar with definition of positioning frequency layer agreed in RAN1, CSI-RS frequency layer can be defined as:   |  | | --- | | * the same SCS and CP type * the same centre frequency * the same value of CSI-RS bandwidth |   **Proposal 2：** The definition of intra-frequency where CSI-RS resource of serving cell is available as follows:   |  | | --- | | * the centre frequency of CSI-RS resources on the target cell configured for measurement is the same as centre frequency of CSI-RS resources on the serving cell configured for measurement, and, * the bandwidth of CSI-RS resources on the target cell configured for measurement is the same as bandwidth of CSI-RS resources on the serving cell configured for measurement, and,   + - the SCS of CSI-RS on serving cell and target cell is the same     - the CP type of CSI-RS on serving cell and target cell is the same |   **Proposal 3：** No requirement will be defined for case 2 in MO configuration. |
| R4-2000463 | MediaTek | **Observation 1:** CSI-RS configuration for mobility can be far more flexible than SSB. A good definition of intra and inter frequency should help reduce the number of scenarios to be address in the spec and reduce UE’s scheduling complexity.  **Observation 2:** SSB-based cell detection is still required for CSI-RS based L3 measurement.  **Observation 3:** The signaling servingCellMO was introduced to avoid UE taking CSI-RS with the same cell ID as its serving cell but in a wrong MO in event evaluation.  **Observation 4:** There is no any UE capability from R15 to further differentiate whether UE is able to handle mix-numerology between CSI-RS and data.  **Observation 5:** The intra-frequency definition has nothing to do with whether the CSI-RS is completely within the DL active BWP or not.  **Proposal 1:** The definition of intra and inter for CSI-RS based L3 measurement should align with SSB as much as possible.  **Proposal 2:** If an MO provides information for both SSB and CSI-RS based measurement, the intra or inter frequency definition for SSB and CSI-RS should be the same.  **Proposal 3:** To avoid contradiction between RAN2 and RAN4 specs, if an MO is indicated as servingCellMO, then it should always be an intra-frequency MO.  **Proposal 4:** UE does not expect the configuration that 2 MOs are configured for the same intra-frequency layer. Network should directly merge the CSI-RS configurations into the same MO.  **Proposal 5:** If there is no strong use case for different SCSs between intra-frequency CSI-RS and DL BWP, RAN4 can add one additional condition that the SCS of intra-frequency CSI-RS resource should have the same SCS as UE’s active DL BWP.  **Proposal 6:** If there is no strong use case for different BWs for CSI-RS resource, RAN4 can add one additional condition that the BW of intra-frequency CSI-RS resource should have be the same as serving cell.  **Proposal 7:** RAN4 to first focus on the requirements of intra-frequency measurement without gap and inter-frequency measurement with gap, and leave the other scenarios for future enhancement.  **Proposal 8:** If an MO configures both SSB and CSI-RS based measurement, then all CSI-RS resources in that MO should cover the SSB in frequency domain.  **Proposal 9:** RAN4 should avoid the case that some of the CSI-RS resources in the MO are intra-frequency and the others are inter-frequency. This has a huge impact to the current CSSF definition and complicates the discussion of UE measurement capability.  **Proposal 10:** Agree on Case 1 to further limit the MO configuration: all CSI-RS resources in the same MO have the same center frequency, BW, SCS, CP type configured.  **Proposal 11:** If an MO configures both SSB and CSI-RS based measurement, then in time domain all CSI-RS resources in that MO should occurs only within the SMTC duration of the same MO.  **Proposal 12:** If CSI-RS of serving cell is not configured, the definition of its intra- and inter-frequency depends on the SSB configured in the same MO if UE is able to measure both SSB and CSI-RS at the same time. Otherwise, there is no requirement. |
| R4-2000583 | CATT | **Observation 1:** From RAN1 perspective, frequency layer for CSI-RS mobility resources is measurement object (MO). And CSI-RS resources in the same MO shall have the same center frequency.  **Proposal 1:** RAN4 will define the RRM requirements for Case 1 and Case 2 MO configuration.  **Proposal 2:** If the CSI-RS resource of serving cell is not available, the MOs configured for CSI-RS based RRM measurement are defined as CSI-RS based inter-frequency measurement.  **Proposal 3:** The definition of intra-frequency measurement and inter-frequency measurement for CSI-RS based RRM measurement shall be defined as follows:   * When CSI-RS resource of serving cell is available   + **CSI-RS based intra-frequency measurement:** a measurement is defined as a CSI-RS based intra-frequency measurement provided that:     - the SCS of CSI-RS on the serving cell and neighbor cell is the same, and     - the CP type of CSI-RS on serving cell and target cell is the same, and       * + It is applied for SCS = 60KHz     - the center frequency of CSI-RS on the serving cell and neighbor cell is the same     - the BW of CSI-RS resources in the same MO is the same   + Otherwise, it can be defined as CSI-RS based inter-frequency measurement. * When CSI-RS resource of serving cell is not available   + the MOs configured for CSI-RS based RRM measurement are defined as CSI-RS based inter-frequency measurement |
| R4-2000584 | CATT | LS on CSI-RS based intra-frequency and inter-frequency Measurement definition |
| R4-2000637 | CMCC | ***Proposal 1:*** *It is proposed to define the CSI-RS based intra-frequency measurement in a similar way as SSB based intra-frequency measurement, and RAN4 can specify measurement requirements for the limited scenarios in Rel-16 to save effort.*  ***Proposal 2:*** *a measurement is defined as CSI-RS based intra-frequency measurement provided that:*   * *the SCS of CSI-RS on the serving cell and target cell is the same* * *the CP type of CSI-RS on serving cell and target cell is the same* * *the centre frequency of CSI-RS on the serving cell and neighbour cell is the same*   ***Proposal 3:*** *it is proposed to specify intra-frequency measurement requirements for the case that all CSI-RS resources in the same MO have the same BW*  ***Proposal 4:*** *for intra-frequency measurement with the case that CSI-RS resources in the same MO have different BW, there are two possible solutions:*   * *Option 1: depending on whether the maximum BW of CSI-RS resource is within active BWP or not, the intra-frequency measurement can be handled as intra-frequency measurement with MG or intra-frequency measurement without MG.* * *Option 2: do not specify RRM requirements in Rel-16*   ***Proposal 5:*** *for CSI-RS based intra-frequency measurement, it is proposed to specify the requirements for both measurement with MG and measurement without MG.*   * Table 1 possible scenarios of CSI-RS based intra-frequency measurement  |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | without associated SSB | with associated SSB | | | | Associated SSB is intra-f w/o MG | Associated SSB is intra-f w/ MG | Associated SSB is inter-f | | Target CSI-RS is fully covered by active BWP | MG is not needed | MG is not needed | MG is needed | | | Target CSI-RS is not fully covered by active BWP | MG is needed | MG is needed | MG is needed | |   ***Proposal 6:*** *for CSI-RS based inter-frequency measurement, it is proposed to specify the requirements for both measurement with MG and measurement without MG.*  Table 2 possible scenarios of CSI-RS based inter-frequency measurement   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | without associated SSB | with associated SSB | | | | Accociated SSB is intra-f w/o MG | Accociated SSB is intra-f w/ MG | Accociated SSB is inter-f | | Target CSI-RS is fully covered by active BWP | Case 1: SCS is same, MG is not needed  Case 2: SCS is different, whether MG/scheduling restriction is needed or not depends on UE capability | | MG is needed | | | Target CSI-RS is not fully covered by active BWP | MG is needed | MG is needed | MG is needed | |   ***Proposal 7:*** *for inter-frequency measurement with target CSI-RS fully covered by active BWP, but has different SCS with serving CSI-RS resource, if UE is capable of simultaneous reception with different numerologies, MG or scheduling restriction is not necessary.* |
| R4-2000656 | Nokia, Nokia Shanghai Bell | **Observation1:** For SSB based measurements in NR, the UE behaves similarly as long as the SSB is completely contained in the active BWP, irrespective of whether the center frequency is the same or not.  **Proposal1:** The definition of intra-frequency and inter-frequency shall take into account the active BWP to better align the UE behavior in different measurement scenarios.  **Proposal2:** The CSI-RS based intra-frequency measurement shall consider the case where the CSI-RS resource of the neighbor cell to be measured is within the active BWP.  **Proposal3:** The CSI-RS based intra-frequency measurement shall consider the case where the CSI-RS resource of the neighbor cell to be measured is partially overlapping with the active BWP, and the UE only measures the part of CSI-RS resource within the active BWP.  **Proposal4:** The CSI-RS based intra-frequency measurement is defined as below:  CSI-RS based intra-frequency measurement: a measurement is defined as a CSI-RS based intra-frequency measurement provided the bandwidth of the CSI-RS resources on the neighbor cell configured for measurement is partially or completely within the active BWP of the UE, and SCS and CP type of the CSI-RS resources of the neighbor cell and the SCS of the serving cell are the same.  **Proposal5:** Measurement gaps are not required for CSI-RS based intra-frequency measurements.  **Proposal6:** It is proposed to first work on the CSI-RS based intra-frequency measurement requirements in RAN4. |
| R4-2000792 | Apple | **Proposal 1:**   * When the SCS of CSI-RS on serving cell and target cell is the same and the CSI-RS resource of the target cell is fully contained within the active BWP of the serving cell, the corresponding CSI-RS L3 measurement is defined as intra-frequency measurement without gap. * When the SCS of CSI-RS on serving cell and target cell is NOT the same or the CSI-RS resource of the target cell is fully contained within the active BWP of the serving cell, the corresponding CSI-RS L3 measurement is defined as inter-frequency measurement.   **Proposal 2:** Multiple intra-frequency measurement objects can be configured for intra-frequency measurements.  **Proposal 3:** In Rel-16, all CSI-RS resources configured in the same measurement object not only have the same center frequency but also have the same bandwidth.  **Proposal 4:** CSI-RS resource bandwidth, density and periodicity should not be used to distinguish between CSI-RS based intra- and inter-frequency measurement. |
| R4-2000946 | NTT DOCOMO | **Observation 1:** The denominator of the CSI-SINR is derived using REs carrying CSI-RS resources. It might be difficult to compare two SINR with different BWs, since measured interference can be different depending on measured frequency.  **Observation 2:** The problem in observation 1 can be avoided by proper NW implementation.  **Proposal 1:** Following case should be applied for MO configuration.   * Case 2: all CSI-RS resources in the same MO have the same center frequency, SCS, CP type configured. BW can be different.   **Observation 3:** If CSI-RS resources of the target cells are fully included in active BWP with the same SCS, the UE can receive them without RF retuning regardless of their frequency location.  **Proposal 2:** Following option should be applied for condition of intra-frequency measurement.   * Option 2: the bandwidth of the CSI-RS on the neighbor cell is within the active BWP of UE   **Observation 4:** Option 2 doesn’t contradict RAN2 specification, since CSI-RS resources with different frequency location can be configured with different MOs.  **Observation 5:** It is relatively easy to specify the requirements of CSI-RS inter-frequency measurement all of CSI-RS resources can be covered by existing gap pattern.  **Proposal 3:** When CSI-RS is not available in the serving cell, the requirements of inter-frequency measurement should be applied. |
| R4-2000994 | OPPO | **Proposal 1:**  A measurement is defined as a CSI-RS based intra-frequency measurement, provide that the center frequency, bandwidth, SCS and CP duration on the serving cell and neighbor cell are the same, and the bandwidth of the CSI-RS on the neighbor cell is within the active BWP of the UE. Otherwise, a measurement is defined as a CSI-RS based inter-frequency measurement.  **Proposal 2:** A measurement for case 2 is defined as a CSI-RS based inter-frequency measurement.  **Proposal 3:** RAN4 just consider RRM requirements for Case 1 MO configuration, and no requirement is defined for case 2 MO configuration. |
| R4-2001014 | NEC | **Observation 1:** SSB based intra/inter frequency measurement definition is defined for measurement object.  **Observation 2:** CSI-RS resources in the same MO shall have same centre frequency and SCS  **Observation 3:** Centre frequency cannot be used for differentiation of intra and inter frequency measurement object based on RAN1 restriction.  **Proposal 1:** A measurement object is defined as a CSI-RS based intra-frequency measurement object provided:   * SCS of CSI-RS on the serving cell and neighbour cell is the same * CP type of CSI-RS on serving cell and target cell is the same (It is applied for SCS = 60KHz) * Bandwidth of the CSI-RS on the neighbour cell is within the active BWP of the UE * Bandwidth of CSI-RS on the target cell is the same as bandwidth of CSI-RS on the serving cell   **Proposal 2:** A measurement object is defined as a CSI-RS based inter-frequency measurement object if it is not intra-frequency measurement object. |
| R4-2001277 | ZTE | **Proposal 1:** The definition of intra-frequency measurement and inter-frequency measurement for CSI-RS based RRM measurement should be defined as follows.  *-* CSI-RS based intra-frequency measurement: a measurement is defined as a CSI-RS based intra-frequency measurement provided  the centre frequency of the CSI-RS resource on the neighbour cell configured for measurement is the same as centre frequency of the CSI-RS resource on the serving cell configured for measurement, and  the bandwidth of the CSI-RS resource on the neighbour cell configured for measurement is the same as bandwidth of the CSI-RS resource on the serving cell configured for measurement, and  the subcarrier spacing of the two CSI-RS resources on the neighbour cell and on the serving cell are the same.  - CSI-RS based inter-frequency measurement: a measurement is defined as a CSI-RS based inter-frequency measurement provided  the centre frequency of the CSI-RS resource on the neighbour cell configured for measurement is not the same as centre frequency of the CSI-RS resource on the serving cell configured for measurement, or  the bandwidth of the CSI-RS resource on the neighbour cell configured for measurement is not the same as bandwidth of the CSI-RS resource on the serving cell configured for measurement, or  the subcarrier spacing of the two CSI-RS resources on the neighbour cell and on the serving cell are the same.  **Proposal 2:** If no CSI-RS resources on serving cell is configured in one measurement object the measurement is inter frequency measurement. The RRM requirements for CSI-RS based inter frequency measurement applies. |
| R4-2001656 | Huawei, HiSilicon | **Proposal 1:** The reference point of centre frequency of CSI-RS resources on the serving cell shall be defined.  **Proposal 2:** CSI-RS based intra-frequency MO shall include the CSI-RS resource indicated in servingcellMO.  **Proposal 3:** The limitation of the same bandwidth of CSI-RS resources on the target cell as bandwidth of CSI-RS resources on the serving cell is not necessary and putting additional restriction on network configuration.  **Proposal 4:** The definition of CSI-RS based intra-frequency measurement can be specified as below:   * the centre frequency of CSI-RS resources on the target cell configured for measurement is the same as centre frequency of CSI-RS resource on the serving cell, if available, indicated for measurement, and, * the SCS of CSI-RS on serving cell and target cell is the same   where all CSI-RS resources from the same MO should have the same centre frequency, otherwise the measurement is defined as a CSI-RS based inter-frequency measurement. |
| R4-2001656 | Huawei, HiSilicon | Reply LS on clarification about CSI-RS measurement |
| R4-2002055 | Qualcomm | **Proposal 1**: RAN4 to define requirements for CSI-RS based measurements for the following CSI-RS configuration only: 48 PRB’s and density D =3.  **Proposal 2**: CSI-RS measurements to be considered intra-frequency if the CSI-RS of neighbor cell has the same location, bandwidth, SCS and CP duration as that of serving cell and the CSI-RS lies within the active BWP.  **Proposal 2a:** All CSI-RS measurements that don’t fall under proposal 1 are considered inter-frequency.  **Proposal 3**: The tuning time for CSI-RS based measurements that are outside UE’s active BWP will be same as that for BWP switch. |

## 3.2 Open issues summary

Agreements on MO configuratoin and definition of intra-frequency and inter-frequency measurement agreed in R4-1913749 in RAN4#93 meeting:

**WF on MO configuration**

* MO configuration
  + Case 1: all CSI-RS resources in the same MO have the same center frequency, BW, SCS, CP type configured.
  + Case 2: all CSI-RS resources in the same MO have the same center frequency, SCS, CP type configured. BW can be different.
* RAN4 will study the RRM requirements at least for Case 1 MO configuration. FFS how to address Case 2.
* Note: this does not exclude defining requirements for Case 2.

**WF on CSI-RS based intra-frequency and inter-frequency measurement definition**

* Case 1: CSI-RS resource of serving cell is available
  + CSI-RS based intra-frequency measurement: a measurement is defined as a CSI-RS based intra-frequency measurement provided that:
    - the SCS of CSI-RS on the serving cell and neighbor cell is the same
    - the CP type of CSI-RS on serving cell and target cell is the same
      * It is applied for SCS = 60KHz
    - the center frequency, bandwidth and active BWP
      * Option 1: the center frequency of CSI-RS on the serving cell and neighbor cell is the same, and
      * Option 2: the bandwidth of the CSI-RS on the neighbor cell is within the active BWP of the UE, and
      * Option 3: the bandwidth of CSI-RS on the target cell is the same as bandwidth of CSI-RS resources on the serving cell
      * Any combination of options above
  + Note 1: the RAN4 design shall not contradict RAN2 agreements on MO signalling
  + Note 2: the definition of intra-frequency and inter-frequency measurement shall not impact RAN1’s agreement on the definition of the same MO
* Case 2: CSI-RS resource of serving cell is not available
  + Option 1: All MO are inter-frequency
  + Option 2: No requirement is applied

### 3.2.1 MO configuration for RRM requirement

**Issue 1-1: Whether define RRM requirement for case 2 in MO configuration?**

* Option 1: Define (CATT, CMCC, NTT DOCOMO, Huawei)
  + Depending on whether the maximum BW of CSI-RS resource is within active BWP or not, the intra-frequency measurement can be handled as intra-frequency measurement with MG or intra-frequency measurement without MG. (CMCC)
  + The limitation of the same bandwidth of CSI-RS resources in one MO is not necessary and putting additional restriction on network configuration. (Huawei)
* Option 2: No requirement (Intel, MediaTek, CMCC, OPPO)
* Recommended WF
  + Need more discussion

### 3.2.2 Intra-frequency and inter-frequency measurement definition

**Issue 2-1: When CSI-RS resource of serving cell is available, a measurement is defined as CSI-RS based intra-frequency measurement provided:**

* the SCS of CSI-RS on the serving cell and neighbor cell is the same
* the CP type of CSI-RS on serving cell and target cell is the same
  + It is applied for SCS = 60KHz
* the centre frequency, bandwidth and active BWP
  + Option 1: the reference is the centre frequency (Intel, CATT, CMCC, ZTE, Huawei, MediaTek)
    - Option 1a: (Intel, ZTE)
      * the center frequency of CSI-RS on the serving cell and neighbor cell is the same
      * the bandwidth of CSI-RS on the target cell is the same as that of CSI-RS resources on the serving cell
    - Option 1b: (CATT)
      * the center frequency of CSI-RS on the serving cell and neighbor cell is the same
      * the BW of CSI-RS resources in the same MO is the same
    - Option 1c: (CMCC)
      * the center frequency of CSI-RS on the serving cell and neighbor cell is the same
    - Option 1d: (Huawei)
      * the centre frequency of CSI-RS resources on the target cell configured for measurement is the same as centre frequency of CSI-RS resource on the serving cell indicated in servingCellMO
    - Option 1e: (MediaTek )
      * If an MO is indicated as *servingCellMO*, then only those CSI-RS resources in this MO can be considered as intra-frequency of the serving cell.
      * the SCS of intra-frequency CSI-RS resource should have the same SCS as UE’s active DL BWP
      * the BW of intra-frequency CSI-RS resource should have be the same as serving cell
  + Option 2: the reference is the active BWP of UE (Nokia, Apple, NTT DOCOMO, OPPO, NEC)
    - Option 2a: (Nokia)
      * the CSI-RS resources on the neighbor cell configured for measurement is partially or completely within the active BWP of the UE
    - Option 2b: (Apple, NTT DOCOMO, OPPO)
      * the bandwidth of the CSI-RS on the neighbor cell is within the active BWP of the UE
    - Option 2c: (NEC)
      * the bandwidth of the CSI-RS on the neighbor cell is within the active BWP of the UE
      * the bandwidth of CSI-RS on the target cell is the same as that of CSI-RS resources on the serving cell
  + Option 2d: the reference is centre frequency and the active BWP of UE (Qualcomm)
    - the center frequency of CSI-RS on the serving cell and neighbor cell is the same
    - the bandwidth of the CSI-RS on the neighbor cell is within the active BWP of the UE
    - the bandwidth of CSI-RS on the target cell is the same as that of CSI-RS resources on the serving cell
* Recommended WF
  + Need more discussion

**Issue 2-2: When CSI-RS resource of serving cell is not available,**

* Option 1: (CATT, NTT DOCOMO, ZTE, OPPO, Huawei)
  + The MOs configured for CSI-RS based RRM measurement are defined as CSI-RS based inter-frequency measurement.
* Option 2: (MediaTek)
  + The definition of its intra- and inter-frequency depends on the SSB configured in the same MO if UE is able to measure both SSB and CSI-RS at the same time. Otherwise, there is no requirement.
* Recommended WF
  + Agree option 1.

## 3.3 Companies views’ collection for 1st round

### 3.3.1 Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Issue 2-1:  Since the definition of CSI-RS based intra-frequency measurement has been discussed for several meetings and little progress has been made. To move forward, CMCC would like to provide a compromise way:   * Define the CSI-RS based intra-frequency measurement in a simple way, e.g. only SCS, CP type, and center frequency are considered. * But for the requirements, we can consider to specify requirements for the limited/selected scenarios to solve companies concern.   We would like to clarify why we prefer to have the definition in a simple way. Firstly, it is not preferred to have too much restriction on the network deployment. Secondly, if we go with the options that BW or active BWP is considered, it will introduce the case that there are both intra-frequency and inter-frequency in the same MO, or it may cause complexity in the requirements specification of UE measurement capability. We also understand companies concern, so if we go with above suggested definition, we can consider to specify requirements for the limited or selected scenarios.  Sub topic 1-2:  ….  Others: |
| ZTE | Issue 1-1: Requirements for case 2 can be specified if time allows. We think case 1 should be prioritized.  Issue 2-1: Comments on some of the options:  Option 1b: the condition ‘the BW of CSI-RS resources in the same MO is the same’ is more related to MO configuration rather than intra-frequency measurement definition. It would be better not to mix the two issues together.  Option 1c: We are also fine with this option.  Option 1d: It seems the same proposal as option 1c if I understand correctly.  Option 1e: We have different understanding about servingCellMO. It is mainly used for UE to identify which CSI-RS resources are of serving cells. The CSI-RS resources of other cells can be configured in servingCellMO or other MOs. It is unnecessary restriction that intra frequency measurement CSI-RS resources have to be configured in servingCellMO. Considering only 96 CSI-RS resources can be configured in one MO, the intra-frequency measurements may only be configured for one or two cells. In our view intra-frequency CSI-RS measurement is more important than inter-frequency. So it should be allowed that intra-frequency measurement can be configured in multiple MOs  Option 2: One of the main issue of this reference is that active BWP could change frequently. One MO is configured as intra frequency measurements in the first place if it is in the active BWP of the UE. When active BWP changes, it becomes inter frequency measurements.  The intra/inter frequency measurements should be defined from system perspective rather than UE perspective. Moreover the change from intra frequency measurements to inter frequency measurements is not known in L3 by which the MO is configured. The BWP change is mostly a L1 behaviour which can be triggered by DCI or timer. It is unknown to L3. So the measurements configured by L3 could exceeds UE capabilities of monitoring inter frequency layer with gaps. |
| CATT | Issue 1-1: Support option1, requirement should be defined for case 2 for MO configuration. CSI-RS BW restriction will have significantly impact on network flexibility.  Issue 2-1: Option1, support to use center frequency to define intra-frequency measurement.  Similar comment as ZTE, if the reference is the active BWP of UE, the intra-frequency measurement can become inter-frequency measurement with the change of active BWP of UE, and it is hard to define the requirement for UE capability.  According to RAN1/RAN2’s understanding, the frequency layer for CSI-RS mobility resources is measurement objet (MO), thus, the definition of intra/inter-frequency should be MO specific. According to 38.331, the SCS and center frequency are MO specific, so as long as the SCS and center frequency is the same, we can consider as intra-frequency measurement.  Similar as SSB based measurement, CSI-RS based measurement can be categorized as follows:   * Intra-frequency measurement without RF tuning (the BW of CSI-RS on target cell is smaller than or equal to that on serving cell) * Intra-frequency measurement with RF tuning (the BW of CSI-RS on target cell is larger than that on serving cell) * Inter-frequency measurement with gap * Inter-frequency measurement without gap |
| Huawei, HiSilicon | Issue 1-1: limitation of the same bandwidth of CSI-RS resources in one MO puts CSI-RS MO configuration restriction to network.  Issue 2-1: option 1d.  1. CSI-RS based intra-frequency MO shall include the CSI-RS resource indicated in servingcellMO;  2. Intra-frequency MO definition can be decouple with measurement gap. An intra-frequency MO can be without gap if all CSI-RS resources are within active BWP.  3. No need to limit the CSI-RS resource bandwidth is same. The reason is mentioned in issue1-1.  Issue 2-2  Agree with the recommended WF. |
| OPPO | Issue 1-1: prefer option 2.  Issue 2-1: Support option 2.  Regarding the comments from CATT and ZTE, the definition of capability would not follow the rules used for SSB, and can focus on the total number of intra-frequency and inter-frequency layers.  And we prefer that a measurement is defined as a CSI-RS based intra-frequency measurement, provide that at least the center frequency, bandwidth, SCS and CP duration on the serving cell and neighbor cell are the same, and the bandwidth of the CSI-RS on the neighbor cell is completely within the active BWP of the UE.  If it is this case, the measurement requirements for CSI-RS based L3 measurement can Avoid complications like what we did for SSB, and could be much clearer like LTE mechanism.   * intra-frequency measurement without gap * inter-frequency measurement with gap   Issue 2-2: Agree with the recommended WF. |
| Nokia, Nokia Shanghai Bell | Issue 1-1: We support Option 1.  UE is only required to measure the CSI-RS within the active BWP. No need to restrict to the same bandwidth in one MO.  Issue 2-1: We support Option2.  The intra-f measurement is understood if the UE can measure neighbour cells simultaneously with serving cell. This can be done if the CSI-RS bandwidth is within the active BWP. We can first study the case where the CSI-RS is fully within the active BWP, so either Option 2a or Option 2b is fine.  As for the same bandwidth, CSI-RSRP is defined as the linear average of the power within the configured bandwidth, so it is normalized to bandwidth and the bandwidth does not have to be the same.  Issue 2-2: This scenario can be down-prioritized until we have the basic requirement for case 1 i.e. CSI-RS is available in both serving and neighbor cells. We can return if some other companies want to re-discuss it. |
| MTK | Issue 1-1:  Support Option 2. Allowing flexible CSI-RS BW is going to complicate the spec because there will be a number of additional scenarios to be further considered in order to be technically correct. Actually we are curious on how much system performance loss is expected if RAN4 spec does not allow this flexibility in CSI-RS BW configuration.  Issue 2-1:  The intra-freq MO needs to be indicated as *servingCellMO.* Otherwise, we are contradicting to RAN2 spec. As we mentioned in previous meetings, the intention of this signalling is to let UE know clear about which MO contains UE’s serving cell, and then some measurement events based on serving cell quality can be configured to that MO. Otherwise, UE may actually detect multiple cells with the same PCID as UE’s serving cell in multiple MOs, and then UE will do the wrong comparison for those configured events.  Furthermore, the intra-/inter-freq definition should be **MO-specific**, not RS-specific. In other words, the SSB and CSI-RS configured in the same MO must have exact the same definition, and all CSI-RS configurations in the same MO must also have exact the same definition, because   1. Allowing both intra-frequency and inter-frequency in one MO is going complicate the spec. And it cannot fit into the current framework of CSSF (**carrier specific** scaling factor). We do not think RAN4 really has the time to re-design the CSSF for CSI-RS L3 measurement and maintain backward compatible to SSB at the same time. 2. This *servingCellMO* is per-MO configured. It is strange and contradicted to RAN2’s understanding if a MO is indicated as *servingCellMO*, but the CSI-RS configurations in this MO are defined as inter-frequency. 3. Allowing both intra-frequency and inter-frequency in one MO actually creates additional frequency layers to be monitored by UE. This consumes the # of layers to be monitored in UE’s measurement capability, increases the value of CSSF which eventually extends the measurement period of all MOs, and complicates UE’s measurement scheduling.   Regarding Option 2, a possible WF is to only define requirements for intra-frequency CSI-RS when the CSI-RS BW is within (FFS partially) the active BWP of UE.  Issue 2-2:  We don’t understand why we want to define the CSI-RS as an inter-frequency if UE still needs to measure the SSB of serving cell and UE can measure the CSI-RS and the SSB at the same time? |
| Apple | Issue 1-1: Support option 2. Without restriction of the same bandwidth in the same MO, we have to face the situation of inter-frequency and intra-frequency in the same MO. I saw CMCC’s proposal to define it based on the relation between the max BW and BWP BW. However, BWP BW can dynamically change even after MO is configured. The issue we faced is still there.  Issue 2-1: if only case 1 is considered, option 2b becomes straightforward since all cases satisfy this condition will have the same requirement. |
| QC | Issue 1-1: Whether define RRM requirement for case 2 in MO configuration?  We would go with option 2. For proponents of option 1, what is the gain to be had from defining requirements for the case where MO has differing BW’s. Can’t the network just configure multiple MO’s for that purpose.  Issue 2-2: When CSI-RS resource of serving cell is not available  A question for clarification, how will this scenario be used for mobility? If there is no comparison to serving cell, how does network decide on mobility. I would say we don’t define any requirements for this case.  Issue 2-1: When CSI-RS resource of serving cell is available, a measurement is defined as CSI-RS based intra-frequency measurement provided:  This has been discussed quite a bit in previous meetings too. Again, a question for clarification, what is the necessity to define differing BW’s as intra-frequency. Since we are talking mobility, you would want to cover the same chunk of BW’s. If the BW’s are not the same, the UE can still do those measurements, we will just label them inter-freq.  Another question, maybe to MTK or moderator, is this a choice between option1 and option2,. I see them as to be separately agreed or not. |
| Ericsson | Issue 1-1: support option 1  Issue 2-1: option 1  Issue 2-2: option 1 |
| DOCOMO | Issue 1-1: To avoid unnecessary restriction in the RAN4 specifications, we prefer option 1.  Issue 2-1: We prefer option 2b. If an active BWP is configured to a UE, the UE is expected to receive physical channels and signals included in the BW. So, if target CSI-RS is fully included in the active BWP, the UE can measure them without measurement gap because RF retuning is not necessary. This discussion is also aligned to the agreement in RAN4 #92bis, that UE can perform SSB-based inter-frequency measurements without measurement gaps if the SSB is completely contained in the active BWP of the UE. On the other hand, when NW wants to configure CSI-RS resources with different center frequency, we can use two different MOs and that doesn’t conflict RAN2 specification (no need to have additional restrictions such as options 1, 2c and 2d).  Issue 2-2: option 1 |
| NEC | Issue 2-1:  We support option 2 as baseline.  The reason for proposing option 2c in particular is:  One assumption (same as SSB) we make is, an MO (all config in a MO) can be only intra-freq or inter-freq MO. Upon BWP change, if all config in a MO do not have the same BW, some config in a MO will be intra freq and some will be inter-freq. Therefore, to avoid that scenario, we support option 2c.  Note: If this assumption is not correct, we can agree to Option 2b. |
| Intel | Issue 1-1: Agree with option 2. If there are multiple bandwidth in the same MO, the MO may involve measurement with and without gap, which is too complex to define requirement.  Issue 2-1: If go with no center-frequency and active BWP method, there are several questions:   * Active BWP is dynamic, intra-frequency measurement may change to inter-frequency. the measurement requirements are different for intra-f measurement and inter-f measurement. * For the same MO, both SSB and CSI-RS can be configured, if the definitions of intra-f measurement are different for SSB and CSI-RS, it will cause confusion. * Bring complex to UE capability requirement. UE capability requirement may need to be modified.   Issue 2-2: Agree with option 1. |

### 3.3.1 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.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## 3.4 Summary for 1st round

### 3.4.1 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.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Issue 1-1:**  Whether define RRM requirement for case 2 in MO configuration? | *Tentative agreements: More discussion is needed*  *Recommendations for 2nd round:*  *Candidate options:*   * *Option 1: define (CATT, CMCC, NTT DOCOMO, Huawei)* * *Option 2: not define (Intel, MediaTek, CMCC, OPPO, Apple)*   *to move forward, can companies accept CMCC’s suggestion on the scenario and definition:*   * Define the CSI-RS based intra-frequency measurement in a simple way, e.g. only SCS, CP type, and center frequency are considered. * Consider to specify requirements for the limited/selected scenarios to solve companies concern. |
| **Issue 2-1:**  When CSI-RS resource of serving cell is available, a measurement is defined as CSI-RS based intra-frequency measurement provided: | *Tentative agreements: More discussion is needed*  *Recommendations for 2nd round:*  *Candidate options:*  *Companies decide the definition should be defined based on the center frequency or based on the active BWP.*   * *Option 1: the same center frequency (Intel, CATT, CMCC,ZTE, MediaTek , Huawei)* * *Option 2: within active BWP of UE (Apple, Nokia, NTT DOCOMO, OPPO, NEC)*   *to move forward, can companies accept CMCC’s suggestion on the scenario and definition:*   * Define the CSI-RS based intra-frequency measurement in a simple way, e.g. only SCS, CP type, and center frequency are considered. * Consider to specify requirements for the limited/selected scenarios to solve companies concern. |
| **Issue 2-2:**  When CSI-RS resource of serving cell is not available, | *Tentative agreements: More discussion is needed*  *Recommendations for 2nd round:*  *Candidate options:*   * *Option 1: (Intel, CATT,ZTE, MediaTek , Huawei, OPPO, NTT DOCOMO)* * *All MO configured for CSI-RS measurement are considered as inter-frequency measurement* * *Option 2: (QC, Nokia, MediaTek)* * *No requirement* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### 3.4.2 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”* |

## 3.5 Discussion on 2nd round (if applicable)

### 3.5.1 Intra-frequency and inter-frequency measurement definition

1st round email discussion conclusions

Issue 2-1: Whether define RRM requirement for case 2 in MO configuration?

Further discuss a compromise proposal from moderator in the 2nd round.

Issue 2-2: When CSI-RS resource of serving cell is available, a measurement is defined as CSI-RS based intra-frequency measurement provided

Further discuss a compromise proposal from moderator in the 2nd round.

Decision on Intra-frequency and inter-frequency measurement definition shall be made no later than in RAN4 #94bis.

**Issue 2-1: Whether define RRM requirement for case 2 in MO configuration?**

*Candidate options:*

* *Option 1: define*
* *Option 2: not define*

*Recommendations for 2nd round:*

*To move forward, can companies accept CMCC’s suggestion on the scenario and definition:*

* *Define the CSI-RS based intra-frequency measurement in a simple way, e.g. only SCS, CP type, and center frequency are considered.*
* *Consider to specify requirements for the limited/selected scenarios to solve companies concern.*

**Issue 2-2: When CSI-RS resource of serving cell is available, the definition of intra/inter-frequency measurement should be defined based on:**

* *Option 1: the same center frequency*
* *Option 2: within active BWP of UE*
* *Option 3: same BW*

*Recommendations for 2nd round:*

*To move forward, can companies accept CMCC’s suggestion on the scenario and definition:*

* *Define the CSI-RS based intra-frequency measurement in a simple way, e.g. only SCS, CP type, and center frequency are considered.*
* *Consider to specify requirements for the limited/selected scenarios to solve companies concern.*

**Issue 2-3: When CSI-RS resource of serving cell is not available, the configured CSI-RS measurement is defined as:**

*Candidate options:*

* *Option 1: inter-frequency measurement*
* *Option 2: no requirement*
* *Recommendations for 2nd round:*

*Moderator suggests companies to provide comments on above candidate options. And possible compromises to move forward are welcome.*

### 2.5.2 Companies views’ collection for 2nd round

**Issue 2-1: Whether define RRM requirement for case 2 in MO configuration?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | We prefer option 2 |
| CATT | Can be compromise to option 2 if the intra-frequency is defined based on SCS, CP type and center frequency. |
| CMCC | We prefer to option 1 to define requirements for case 2, but to move forward, we can compromise to option 2. |
| HiSilicon | Prefer Option 1.  The definition of MO in RAN1 only considers SCS and center frequency, we would not change the agreement in RAN1. If RAN4 don’t define the requirements for the different BW case (case2), then it implies that network will have to configure the MO in which CSI-RS resources have same BW. If there are multiple cells with CSI-RS resources with different bandwidth, then network will configure **multiple** MOs for the UE. This will increase the to-be-measured MO number. However for certain UE, the supported CSI-RS MO number is very limited. |

**Issue 2-2: When CSI-RS resource of serving cell is available, the definition of intra/inter-frequency measurement should be defined based on:**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | I am not sure why the same BW got removed from definition. I have added it back. There was a question asked to the proponents who are proposing different BW’s in round 1 to which no answer was given. So I repeat the question here, For mobility between intra-frequency cells the network would want to compare the same chunk of BW’s to see which one is better from UE’s POV. That is why we would want to have BW included in intra-frequency definition. Can someone please explain why this should not be included? |
| CATT | To QC:  In my understanding, the intra-frequency layer should be defined based on MO specific, since MO is frequency layer according to RAN1/RAN2’s agreement. However, BW is not a MO specific parameter. Thus we think the same bandwidth is not the condition to define intra-frequency layer. To move forward, we can compromise to prioritize some scenario for the requirement, e.g. define the requirement for the same BW. For the definition of frequency layer, we would like to align with other group. |
| CMCC | If the same BW is considered, the issue is that there may be intra-f measurement and inter-f measurement in the same MO, since configuration of MO is up to network, and there could be different BW for different resources according to the definition of same MO in RAN1/2.  If within active BWP is considered, there are several issues. Firstly, there may be intra-f measurement and inter-f measurement in the same MO. Secondly, after the BWP switch, the intra-f measurement will be changed to inter-f measurement, or vice versa. Thirdly, different MO will be considered as the intra-f measurement, which will have impact on the UE measurement capability.  Considering above issues, we suggest to define intra-f measurement only considering the center frequency, CP and SCS. For this definition, according to previous discussion, there are mainly two concerns. The first concern is the impact of different BW on UE measurement behavior. For this concern, we can compromise to consider to specify requirements for limited/selected scenario, e.g. the same BW can be considered when specify the requirements. The second concern is that there will be intra-f with MG, intra-f without MG, inter-f with MG, inter-f without MG. For this concern, since the timeline is limited, we can consider to specify requirements for intra-f without MG, inter-f with MG. |
| Huawei, HiSilicon | Support Option 1.  @Qualcomm, in one MO the time-frequency domain of CSI-RS resources are different (see the CSI-RS resource configuration, the CSI-RS may be at different OFDM symbols), thus the interference is always different in time domain. Limiting the bandwidth in frequency domain can’t guarantee the interference level from each to-be-measured cells are same. |

**Issue 2-3: When CSI-RS resource of serving cell is not available, the configured CSI-RS measurement is defined as:**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | We would prefer option 2 with the same logic as the comment made in Issue 2-2. |
| CATT | In my understanding, this scenario is possible. Network can configure Event A4 (Neighbour becomes better than threshold) for CSI-RS measurement. |
| Huawei, HiSilicon | Support Option 1. |

## 3.6 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”* |

# 4 Topic #3: Others (AI 8.16.1.6)

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

## 4.1 Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000466 | MediaTek | **Observation 1:** In current TS38.213 it has clearly specified that the SSB cannot be pre-empted.  **Observation 2:** One of the reason to preclude SSBs in the pre-emption is that SSBs are also required by neighboring cells UEs for L3 mobility purposes. These UEs are not able to monitor DCI format 2\_1 from their neighboring cells.  **Observation 3:** CSI-RS for L3 measurement is also required by UE in neighboring cells, but it is not precluded in TS38.213 at this moment.  **Proposal 1:** The indication by the DCI format 2\_1 is not applicable to receptions of CSI-RS for L3 measurement. Send an LS to RAN1 to update TS38.213. |
| R4-2000467 | MediaTek | RAN4 would like to kindly inform RAN1 that RAN4 has reached consensus that the CSI-RS for layer 3 measurement should not be pre-empted by DCI format 2\_1 because the CSI-RS are also intended to be received by neighbouring cell UEs which are unable to monitor DCI format 2\_1 transmitted from their neighbouring cells. |
| R4-2001648 | Huawei, HiSilicon | **Proposal 1:** When CSI-RS resource for mobility is configured without associated SSB, the CSI-RS measurement requirements apply provided that receive timing difference between the CSI-RS resource and the serving cell is within X, where X is [CP/2 corresponding the SCS of CSI-RS].   * RAN4 to further study the measurement performance with timing error larger than half CP.   **Proposal 2:** When CSI-RS resource for mobility is configured with associated SSB, the CSI-RS measurement requirements is not conditioned on network synchronization.  **Proposal 3:** When CSI-RS resource for mobility is configured with associated SSB, but is not QCL-ed with the associated SSB, timing error should be considered in the CSI-RS measurement requirements. |

## 4.2 Open issues summary

### 4.2.1 Pre-emption on CSI-RS L3 measurement

**Issue 1-1: Whether CSI-RS based L3 measurement shall be precluded in the pre-emption?**

* Option : Yes (MediaTek)
  + The indication by the DCI format 2\_1 is not applicable to receptions of CSI-RS for L3 measurement. Send an LS to RAN1 to update TS38.213
* Recommended WF
  + Agree the proposal from MediaTek

### 4.2.2 Synchronization assumption for CSI-RS measurement requirements

**Issue 2-1: Synchronization assumption for CSI-RS measurement requirements**

* Proposal : (Huawei)
  + When CSI-RS resource for mobility is configured without associated SSB, the CSI-RS measurement requirements apply provided that receive timing difference between the CSI-RS resource and the serving cell is within X, where X is [CP/2 corresponding the SCS of CSI-RS].
    - RAN4 to further study the measurement performance with timing error larger than half CP.
  + When CSI-RS resource for mobility is configured with associated SSB, the CSI-RS measurement requirements is not conditioned on network synchronization.
  + When CSI-RS resource for mobility is configured with associated SSB, but is not QCL-ed with the associated SSB, timing error should be considered in the CSI-RS measurement requirements.
* Recommended WF
  + Need more discussion

## 4.3 Companies views’ collection for 1st round

### 4.3.1 Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CMCC | Issue 1-1:  From our point of view, more discussion is needed on whether it is necessary to send LS to RAN1 to update TS 38.213. Firstly, DL pre-emption is a Rel-15 feature, we are not sure whether it is a good approach to change RAN1 Rel-15 spec. Secondly, on which time/frequency resource that pre-emption is performed is up to network implementation. So may be this issue can be left to network implementation.  Sub topic 1-2:  ….  Others: |
| ZTE | Issue 2-1: When no associated SSB has been configured, a serving cell should be indicated for timing synchronization. It means the neighbor cell is synchronized to the serving cell. In this case the timing difference from UE perspective can be the MRTD of synchronized DC or CA. |
| CATT | Issue 1-1: Generally, we are fine with MTK’s proposal, FFS on how to implement in spec.  Issue 2-1: For non-associated SSB case, we think it applies in synchronized network, e.g. TDD cells. Thus, we think the cell phase synchronization accuracy requirement shall be applied. |
| Huawei, HiSilicon | Issue 2-1: The proposals have been made for many meetings but were not discussed. We understand they should be agreeable based on RAN1 spec (the timing reference for CSI-RS with and without associated SSB) as well as the WID (single FFT for sync case). In both cases, there could be timing error for the CSI-RS measurement, which may impact the measurement performance, and we suggest to study it as early as possible. Anyway, we appreciate more opinions on this issue. |
| Nokia, Nokia Shanghai Bell | Issue 1-1: This shall be firstly discussed in RAN1. After RAN1 designs the preemption principle, RAN4 can continue with the requirements.  Issue 2-1: This can be further discussed. |
| MTK | Issue 1-1:  Pre-emption is a Rel-15 feature. The corresponding RAN1 design are finished, but RAN1 does not address the inter-action to CSI-RS for L3 measurement. The intention of the LS is to trigger RAN1 discussion and it is eventually up to RAN1 which release they want to revise. Eventually this issue should be avoided by network. If network can guarantee this never happen, then it hurts nothing to capture a clear rule in spec.  Issue 2-1:  No matter for the case with or without associated SSB, it is already captured clearly in the WID that UE will use a single FFT to measure the CSI-RS on one frequency layer. In our view, the FFT timing reference should be based serving cell for intra-frequency and one arbitrary cell for inter-frequency layer. Then the issues becomes whether and how RAN4 is going to deal with the cell with long propagation delay such that the degradation on measurement performance is expected. Note that the degradation is also expected even for CSI-RS with associated SSB. RAN4 can either leave it with no requirement, or try to specify a relaxed requirement. Either way is OK to us. |
| Apple | Issue 1-1: at least, in RAN4 test and requirement, we can exclude the case where CSI-RS for L3-measurement is pre-empted.  Issue 2-1: this can be much smaller than the cell phase error. How we can guarantee NW to achieve this?Also the proposal is not clear that “receive timing difference between the CSI-RS resource and the serving cell is within X”. It should be defined as synchronization in both SFN and slot boundary level. |
| Ericsson | Issue 1-1: agree with CMCC, no need to send LS  Issue 2-1: needs further discussion |
| DOCOMO | Issue 2-1: We are not sure the necessity of such requirement, since the cell indicated cellID should include associate SSB |
| NEC | Issue 1-1: Agree with Nokia. |

### 4.3.2 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.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## 4.4 Summary for 1st round

### 4.4.1 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.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Issue 1-1:**  Whether CSI-RS based L3 measurement shall be precluded in the pre-emption? | *Recommendations for 2nd round: Need more discussion*  *No option is recommended, since it is the first time to discuss this issue, companies have different views on how to handle this issue.* |
| **Issue 2-1:**  Synchronization assumption for CSI-RS measurement requirements | *Recommendations for 2nd round: Need more discussion, companies can provide their views on timing difference for non-associated case.*  *Candidate options:*  *Option 1: RAN4 further discuss the synchronization assumption for CSI-RS measurement (Huawei, CATT, Nokia, Ericsson)*  *Option 2: no need such requirement. (NTT DOCOMO)* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### 4.4.2 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”* |

## 4.5 Discussion on 2nd round (if applicable)

### 4.5.1 Pre-emption on CSI-RS L3 measurement

**Issue 1-1: Whether CSI-RS based L3 measurement shall be precluded in the pre-emption?**

* Option : Yes (MediaTek)
  + The indication by the DCI format 2\_1 is not applicable to receptions of CSI-RS for L3 measurement. Send an LS to RAN1 to update TS38.213
* Recommendations for 2nd round:

*Moderator suggests companies to provide comments on issue 1-1.*

### 4.5.2 Synchronization assumption for CSI-RS measurement requirements

**Issue 2-1: Synchronization assumption for CSI-RS measurement requirements**

*Candidate options:*

* Option 1: RAN4 further discuss the synchronization assumption for CSI-RS measurement
* Option 2: no need such requirement.
* Recommendations for 2nd round:

*Moderator suggests companies to provide comments on* synchronization assumption *for non-associated case.*

### 4.5.3 Companies views’ collection for 2nd round

**Issue 1-1: Whether CSI-RS based L3 measurement shall be precluded in the pre-emption?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | Firstly, we can reach the consensus in RAN4, and defer the LS to next meeting. |
| CMCC | From our point of view, it is not necessary to send LS to RAN1 to update TS 38.213. Considering that on which time/frequency resource that pre-emption is performed is up to network implementation. This issue can be left to network implementation. Anyway, this is the first time to discuss this issue, more discussion is needed. |

**Issue 2-1: Synchronization assumption for CSI-RS measurement requirements**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Let’s start with intra-frequency case and leave inter-frequency to next meeting. For intra-frequency case, can we agree that UE will be using serving cell timing even for neighbor cell measurement. The question then becomes what will be the max assumed timing difference between the cells and for this purpose we can use MRTD. The obvious trouble with using a large value for this timing offset is that the performance requirements will be loose. |
| CATT | The same view as QC. For intra-frequency case, current MRTD value can guarantee the measurement performance, |
| Huawei, HiSilicon | We should differentiate the case with associated SSB and without associated SSB.  - When CSI-RS is configured with associated SSB, UE will use the timing derived from the detected SSB. We understand this is same as for SSB based measurement, and there is no condition on network synchronization. Of course, there can still remain some timing error e.g. when the CSI-RS is not QCL-ed with the SSB.  - When CSI-RS is configured without associated SSB (whether we define requirements for this case is a separate discussion), UE will use the timing of indicated serving cell, and the measurement requirements are conditioned on network synchronization. We are open to discuss the assumption for network synchronization, but the requirements should account for the assumed timing error. |

## 4.6 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”* |