**3GPP TSG RAN WG1 #104-e R1-20xxxxx**

**e-Meeting, January 25th – February 5th, 2021**

**Agenda Item: 7.2.11**

**Source: Moderator (AT&T)**

**Title: Summary of email discussion/approval [104-e-NR-UEFeatures-eMIMO-04]**

**Document for:** **Discussion/Decision**

# Introduction

This document presents the summary of email discussion/approval [104-e-NR-UEFeatures-eMIMO-04] during RAN1 #104-e. According to the Chairman’s Notes:

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| [104-e-NR-UEFeatures-eMIMO-04] Email discussion/approval of whether/how Section 5.2.1.6 in 38.214 applies to FGs 16-1a-1 and 16-1g, till 1/29 (Ralf, AT&T) |

The following was discussed and agreed during RAN1 #104-e within the scope of [104-e-NR-UEFeatures-eMIMO-04]. All proposals are based on the latest RAN1 UE features list for Rel-16 NR in [1].

# Summary of email discussion/approval [104-e-NR-UEFeatures-eMIMO-04]

During RAN1 #103-e, the following was agreed.

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| **Conclusion:** * **For FGs 16-1a-1 and 16-1g, continue discussion on whether/how Section 5.2.1.6 in 38.214 applies**
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Consequently, the topic was addressed by several contributions in RAN1 #104-e as summarized below.

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| Company | Summary |
| Intel Corporation [2] |

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| 5.2.1.6 CSI processing criteria…In any slot, the UE is not expected to have more active CSI-RS ports or active CSI-RS resources in active BWPs than reported as capability. NZP CSI-RS resource is active in a duration of time defined as follows. For aperiodic CSI-RS, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS. For semi-persistent CSI-RS, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. For periodic CSI-RS, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released. If a CSI-RS resource is referred *N* times by one or more CSI Reporting Settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted *N* times. |

In our view the corresponding text from TS 38.214 was designed in Rel-15 and doesn’t relate to FG 16-1g defined in Rel-16. Moreover, some reference signals covered by FG 16-1g and used for pathloss measurement, BFD, RLM and new beam identification, are not associated with any CSI reporting procedures defined by Section 5.2.1.6 and, therefore, should not be considered applicable to the text in TS 38.214. In addition, counting of SSB reference signal is not defined by Section 5.2.1.5. It is therefore natural to restrict applicability of the corresponding text on active CSI-RS resources in Section 5.2.1.6 to conventional CSI (LI, CRI, RI, PMI, CQI) reported using L1 procedures. On the other hand, some clarification on “to measure within a slot” and “per slot” is required for newly defined FGs 16-1g and 16-1a-1 respectively. In particular given periodic nature of the reference signals used for pathloss measurement, BFD, RLM and new beam identification and lack of CSI reference resource definition for such measurements, it is natural to assume that the corresponding reference signals should be always counted even in slots where they do not occur. Similarly, the above counting approach for active reference signals can be also defined for SSB and periodic NZP CSI-RS used for L1-RSRP and L1-SINR. Finally, counting of aperiodic and semi-persistent CSI-RS for L1-RSRP and L1-SINR may follow the principles defined in Section 5.2.1.5 for conventional CSI reporting. The corresponding clarifications are better to be added directly in TS 38.306. Regarding counting of the active reference signal resource if it is referred multiple times for different usages. Due to different requirements and possible different metric for measurements, we propose to double count if the same resource is used for BFD/RLM/NBI/PL RS and L1-RSRP/L1-SINR. For all other cases, double counting for the same reference signal resource should not be applied. **Proposal:*** Restrict definition of active CSI-RS resources defined in Section 5.2.1.6 of TS 38.214 to resource used for conventional CSI (CRI,RI,PMI,CQI,LI) reported using L1 procedures
* Add clarification to “measure within a slot” and “per slot” in FGs 16-1g and 16-1a-1 in TS 38.306 as follows
	+ aperiodic CSI-RS is considered active, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS.
	+ semi-persistent CSI-RS is considered active, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied.
	+ periodic CSI-RS or SSB is considered active, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released.
* Double count active reference signal resource only if the resource is used for BFD/RLM/NBI/PL RS and L1-RSRP/L1-SINR
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| Huawei/HiSilicon [3] | For the purpose of CSI reporting, a description of ‘active’ CSI-RS resources or ports is captured in Section 5.2.1.6 in 38.214, where a rule of double-counting is also specified.

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| 38.214, Section 5.2.1.6In any slot, the UE is not expected to have more active CSI-RS ports or active CSI-RS resources in active BWPs than reported as capability. NZP CSI-RS resource is active in a duration of time defined as follows. For aperiodic CSI-RS, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS. For semi-persistent CSI-RS, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. For periodic CSI-RS, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released. If a CSI-RS resource is referred *N* times by one or more CSI Reporting Settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted *N* times. |

There are mainly two questions to be answered and our views are provided below. During which time will one RS be considered as active?For FG 16-1g, a long time was spent to create component 1 and 2 to distinguish ‘configured to measure’ and ‘configured’. If a periodic RS is considered active between configuration and releasing, then the intended difference between component 1 and 2 of FG 16-1g disappears. For this reason, it is more natural that the previous/existing text in 38.214 do not apply to FG 16-1g, with which the RS resource is counted only in the slot it occurs. Similar logic also apply to ‘per slot limitations’ and ‘memory limitations’ in FG 16-1a-1. According to the latest discussions in [103-e-NR-UEFeatures-eMIMO-01], it seems companies are fine with this clarification and it would be better to capture this (to avoid the chance of mis-interpretation that may rise from current specs). How many times will one RS be counted, if it is associated with different usage?One motivation for introducing FG 16-1g is to allow for sharing of processing capability among different usages. There was a long discussion on whether to mention ‘unique’ in the description of FG 16-1g. In its current form, it says ‘number of SSB/CSI-RS/CSI-IM resources’, where uniqueness is implied and double-counting is thereby not applicable (unless otherwise specified, such as the case when CSI-RS is configured as CMR without dedicated IMR). There was a compromise proposal from QC that is each resource occurrence is counted once for all usages not referred to any report setting, and is counted additional N times if referred N times by one or more CSI Reporting Settings. For this compromise proposal, in our view, so far all the functionalities included in FG 16-1g require only simple measurements and can be shared across functionalities (for example, CSI measurement are not included here), with which it is less motivated to introduce such a double-counting rule. **Proposal:** For FGs 16-1a-1 and 16-1g, the reported capability on number of resources ‘configured to measure’ are counted only in slot where it occurs, and double-counting is not applied if one resource is associated with multiple usages. |
| Apple [4] | We address one remaining issue from the last meeting in term of how to count for the active resource that UE can measure simultaneously within a reference slot for FG2-24, FG16-1a-1, FG16-1g, FG16-1g-1, including L1-RSRP, L1-SINR, PLRS, RLM, BFD and CBD in the following four areas * Time duration of active RS
* Uniqueness of active RS
* Unit for active RS
* Default behavior handling

**Time duration** * For both SSB and CSI-RS, they are counted in the reference slot that overlaps with the actual slot in which the corresponding reference signals are transmitted

**Uniqueness of RS*** For SSB
	+ It is counted only once when SSB is configured for one or multiple of L1-RSRP, PLRS, CBD, RLM and BFD
		- P3 procedure is considered as L1-RSRP as well
	+ It is always double counted when SSB is configured for L1-SINR
* For CSI-RS
	+ It is counted only once when CSI-RS is configured for one or multiple of L1-RSRP, PLRS and CBD
		- P3 procedure is considered as L1-RSRP as well
	+ It is counted only once when CSI-RS is configured for one or multiple of RLM and BFD
	+ It is always double counted when SSB is configured for L1-SINR
* Note: “double counted” means the “If a resource is referred N times by one or more CSI Reporting Settings, the resource is counted N times.” from 38.214

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|   | SSB | CSI-RS |
| PL RS, CBD,L1-RSRP (including P3) | Counted once | Counted once |
| RLM, BFD | Counted once |
| L1-SINR | Double counted | Double counted |

**Unit for resource counting*** SSB: per SSB index
* CSI-RS: per NZP-CSI-RS-Resource

**Default behavior handling*** Default RLM/BFD (RS QCL for PDCCH decoding)
	+ Yes, they should be counted
* CBD fall back from BFRA to CBRA
	+ We are fine for CBD in CBRA not counted (in FG2-31, FG16-1g, FG16-1g-1)
* P3: report quantity of “none” and corresponding NZP-CSI-RS-ResourceSet with Repetition set to “on”
	+ Yes, they should be counted for FG2-24, FG16-1g and FG16-1g-1 as L1-RSRP measurement
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| Qualcomm [5] | For FG 16-1g and 16-1g-1, a remaining issue is how to count the resources configured to measure within a slot in Component 1. We prefer to honor the corresponding rule in 5.2.1.6, i.e. the resource is counted N times if referred N times by any CSI report config. However, we are fine to count the resource once for all its usages if it is not referred by any CSI report config. **Proposal:** * For FG 16-1g and 16-1g-1, each resource occurrence is counted once for all usages not referred to any report setting, and is counted additional N times if referred N times by one or more CSI Reporting Settings
	+ E.g. if a SSB is configured for BFD/RLM/NBI/PL RS/L1-RSRP/L1-SINR CMR, it is counted as 3: 1 for BFD/RLM/NBI/PL RS, 1 for L1-RSRP, and 1 for L1-SINR CMR
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| vivo [6] | The following paragraph in section 5.2.1.6 in 38.214 defines active NZP CSI-RS resources. Our understanding is that this part is not applicable for CSI-RS resources counting for beam management related measurement, e.g. L1-RSRP measurement capability 2-24. It is already stated in 38.306 and 38.322 that 2-24 counting is based on “configured to measure per slot” basis, as in the following statement: “The max number of SSB/CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured to measure L1-RSRP within a slot shall not exceed MB\_1”. The counting of active CSI-RS ports or active CSI-RS resources defined in 38.214 is not based on above “configured to measure per slot” basis, but rather on “active in a duration of time” basis. Such different counting basis make the description in 38.214 not applicable for beam related measurement. This issue has been extensively discussed in RAN1 #101e maintenance session. Majority companies share the understanding. Similarly, for L1-SINR related beam measurement, section 5.2.16 in 38.214 should also not be applicable.

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| NZP CSI-RS resource is active in a duration of time defined as follows. For aperiodic CSI-RS, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS. For semi-persistent CSI-RS, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. For periodic CSI-RS, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released. If a CSI-RS resource is referred N times by one or more CSI Reporting Settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted N times. |

**Proposal:*** Active duration defined in section 5.2.1.6 in 38.214 does not apply to 16-1a-1 and 16-1g
* For RS counting in 16-1a-1 and 16-1g, if they are “configured to measure” or they are counted in per slot limitation, they are counted only in the slot there is the RS
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Companies are invited to express their views on the following:

1. Whether any changes to Section 5.2.1.6 of TS 38.214 are needed. If so, please provide the text proposal.

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| Company | Comments/Questions/Suggestions |
| Ericsson | No changes are needed – the text in 5.2.1.6 is not applicable to 16-1a-1 and 16-1g |
| LG | Same view with Ericsson |
| Huawei, HiSilicon | We agree with Ericsson that the text in 5.2.1.6 is not applicable to 16-1a-1 and 16-1g, and we suggest reflecting this somewhere somehow, e.g., via a conclusion in Chairman’s notes.  |

The following summarizes potential changes to existing feature groups in [1].

**Proposal 1:**

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| 16-1a-1 | SSB/CSI-RS for L1-SINR measurement | Per slot limitations:1. The max number of SSB/CSI-RS (1Tx) for CMR
2. The max number of CSI-IM/NZP-IMR resources
3. The max number of CSI-RS (2Tx) resources for CMR

Memory limitations:1. The max number of SSB/CSI-RS resources as CMR
2. The max number of CSI-IM/NZP IMR resources

Other limitations:1. Supported density of CSI-RS (CMR)
2. The max number of aperiodic CSI-RS resources across all CCs configured to measure L1-SINR (including CMR and IMR) shall not exceed MD\_1
3. Supported SINR measurements
 | 2-21, 2-22 or 2-23, 2-23a | Yes  | N/A |  | Per band | No | No |  | Component 1: Candidate values {8, 16, 32, 64}Component 2: Candidate values {8, 16, 32, 64}Component 3: Candidate values {0, 4, 8, 16, 32, 64}Component 4: Candidate values {8, 16, 32, 64 , 128}Component 5: Candidate values {8, 16, 32, 64 , 128}Component 6: Candidate values {‘1 only’, ‘3 only’, ‘1 and 3’}Component 7: Candidate values {2, 4, 8, 16, 32, 64}Component 8: Candidate values: bitmap with entries {SSB as CMR with dedicated CSI-IM, SSB as CMR with dedicated NZP IMR, CSI-RS as CMR with dedicated NZP IMR configured, CSI-RS as CMR without dedicated IMR configured} If a UE supports FG 16-1a-1 it must support CMR(CSI-RS) + dedicated CSI-IM Note1: The reference slot duration is the shortest slot duration defined for the FR where the reported band belongsNote2: For component 4 and 5 the configured CSI-RS resources for both active and inactive BWPs are countedNote3: For components 1, 2 and 3, CSI-RS resources configured as CMR without dedicated IMR are counted both as CMR and IMRNote4: For components 1, 2 and 3, a SSB/CSI-RS resource is counted only in a slot where it occursNote5: Aperiodic CSI-RS is considered active, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS. Note6: Semi-persistent CSI-RS is considered active, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. Note7: Periodic CSI-RS or SSB is considered active, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released.Note8: Active reference signal resources are counted [once/N times] if the resource is used for BFD/RLM/NBI/PL RS Note9: Active reference signal resources are counted [once/N times] if the resource is used for L1-RSRPNote10: Active reference signal resources are counted N times if the resource is used for L1-SINRNote11: Counting a resource N times means a resource is referred N times by one or more CSI Reporting Settings | Optional with capability signaling |

1. Whether changes to FG 16-1a-1 are needed. If so, please provide the text proposal. Ideally, text proposals are provided as modifications of the proposals above and in consideration of companies’ comments made previously.

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| Company | Comments/Questions/Suggestions |
| Ericsson | Note 8,9 is not applicable to 16-1a-1, which only discusses L1-SINR Support Note4. Do not support notes 5,6,7,8,9,10,11.  |
| Apple | Note 4:Since we need to consider different SCS, we suggest to clarify as Note4: For components 1, 2, 3, 7, a SSB/CSI-RS resource is counted only in a slot that overlaps with the actual slot in which the corresponding reference signals are transmittedNote 8/9/10 is not needed  |
| ZTE | Notes 4~11 is not needed. As a basic description for component 1~3, we have a hat of “Per slot limitations”, and so even without Note-4, we do not see any ambiguities.  |
| LG | In our view, the issues that proposed notes are trying to address is not only applicable to this FG but rather applicable to all other Rel-15/16 FGs related to RS resources ‘within a slot’ or ‘configured to be measured’. We prefer to align the definition of ‘per-slot limitation’ and ‘memory limitation’ across all related Rel-15/16 FGs, which could be handled by RAN2. Thus, we don’t prefer adding note 4~11 on this specific FG. |
| Docomo | Support Note 4 only. Also fine with Apple’s update. |
| Intel | L1-SINR should be reported based on the CSI reference resource, therefore, we prefer the same way of active CSI-RS handling to the rules defined for CSI-RS for CSI purpose (with extension to SSB), i.e. support clarifications in Notes 4, 5, 6.  |
| Huawei, HiSilicon  | Support Note 4, and do not support Note 5~11. |
| vivo | Note 4 and Note 5/6/7 are in two different directions. They are counted either per slot or counted through active duration, but not both.Our understanding is more aligned with what is described in Note 4, which is in line with what we have for L1-RSRP.For counting multiple times if associated with multiple reporting settings, we are fine to count them multiple times. |

**Proposal 2:**

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| 16-1g | Resources for beam management, pathloss measurement, BFD, RLM and new beam identification  | 1. The maximum total number of SSB/CSI-RS/CSI-IM resources configured to measure within a slot across all CCs in one frequency range for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, RLM and new beam identification
2. The maximum total number of SSB/CSI-RS/CSI-IM resources configured across all CCs in one frequency range for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, RLM and new beam identification
 | 2-24, 2-31 | Yes | N/A |  | Per UE | No | Yes |  | Component-1: candidate value set is {2, 4, 8, 12, 16, 32, 64, 128}Component-2: candidate value set is {2, 4, 8, 12, 16, 32, 40, 48, 64, 72, 80, 96, 128, 256}Note: For RS configured for new beam identification, they are always counted regardless of beam failure eventNote: The “configure to measure” RS (component1) only counts those in active BWP but the configured RS (component2) counts all configured including both active and inactive BWPNote: the reference slot duration is the shortest slot duration defined for the reported FR supported by the UENote3: The “configured to measure” RS is only counted in a slot where it occursNote4: Aperiodic CSI-RS is considered active, starting from the end of the PDCCH containing the request and ending at the end of the PUSCH containing the report associated with this aperiodic CSI-RS. Note5: Semi-persistent CSI-RS is considered active, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. Note6: Periodic CSI-RS or SSB is considered active, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released.Note7: Active reference signal resources are counted [once/N times] if the resource is used for BFD/RLM/NBI/PL RS Note8: Active reference signal resources are counted [once/N times] if the resource is used for L1-RSRPNote9: Active reference signal resources are counted N times if the resource is used for L1-SINRNote10: Counting a resource N times means a resource is referred N times by one or more CSI Reporting Settings | Optional with capability signaling |

1. Whether changes to FG 16-1g are needed. If so, please provide the text proposal. Ideally, text proposals are provided as modifications of the proposals above and in consideration of companies’ comments made previously.

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| Company | Comments/Questions/Suggestions |
| Ericsson | Support note 3. Do not support note 4,5,6,7,8,9,10. As Huawei writes, * RSs can only be counted in the slot where they occur, otherwise there is no difference between the two subcomponents of 16-1g
* the feature was introduced by the request of UE vendors to allow pooling of resources. There has been a discussion about adding “unique”, but it was deemed to be unnecessary, since it was implied. Arguing for double counting points into a direction that pooling cannot be applied. We appreciate the effort Apple made to compare the complexity of the various operations, but the rules become far too complicated.
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| Apple | Note 4:Since we need to consider different SCS, we suggest to clarify as Note4: The “configured to measure” RS is counted only in a slot that overlaps with the actual slot in which the corresponding reference signals are transmittedNote 7:needs to separate at least BFD/RLM from CBD/PLRS  |
| ZTE | We are fine with note 3, but do not support other update. |
| LG | In our view, the issues that proposed notes are trying to address is not only applicable to this FG but rather applicable to all other Rel-15/16 FGs related to RS counting. We prefer to align the way of counting RSs across all related Rel-15/16 FGs, which could be handled by RAN2. Thus, we don’t prefer adding note 3~10 on this specific FG. |
| Docomo | Support Note 3 only. |
| Intel | Prefer the same handling of active CSI-RS in the same way to the rules defined for CSI-RS used for CSI purpose, i.e. support clarifications in Notes 4, 5, 6. RE to Huawei, Ericsson: there is difference between two sub-components when CSI-RS resource is configured as aperiodic or semi-persistent CSI-RS (if allowed by the corresponding usage).  |
| Huawei, HiSilicon  | Support Note 3, and do not support Note 4~10. |
| vivo | Note 3 and Note 4/5/6 are in two different directions. They are counted either per slot or counted through active duration, but not both.Our understanding is more aligned with what is described in Note 3, which is in line with what we have for L1-RSRP. |

**Proposal 3:**

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| 16-1g-1 | Resources for beam management, pathloss measurement, BFD, RLM and new beam identification across frequency ranges | 1. The maximum total number of SSB/CSI-RS/CSI-IM resources configured to measure within a slot across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, RLM and new beam identification
2. The maximum total number of SSB/CSI-RS/CSI-IM resources configured across all CCs for any of L1-RSRP measurement, L1-SINR measurement, pathloss measurement, BFD, RLM and new beam identification
 | 2-24, 2-31, 16-1g | Yes  | N/A |   | Per UE | No | No |   | Component-1: candidate value set is {2, 4, 8, 12, 16, 32, 64, 128}Component-2: candidate value set is {2, 4, 8, 12, 16, 32, 40, 48, 64, 72, 80, 96, 128, 256}Note: This FG indicates the maximum number of resources across all FR(s) that are supported by the UENote: The signalled values apply to the shortest slot duration defined in any FR(s) that are supported by the UE Note: The “configured to measure” RS is only counted in a slot where it occursNote: If a CSI-RS resource is associated with multiple usages, the CSI-RS resource is only counted one time | Optional with capability signaling |

1. Whether changes to FG 16-1g-1 are needed. If so, please provide the text proposal. Ideally, text proposals are provided as modifications of the proposals above and in consideration of companies’ comments made previously.

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| Company | Comments/Questions/Suggestions |
| Ericsson | Support both added notes. |
| Apple | Note4: The “configured to measure” RS is counted only in a slot that overlaps with the actual slot in which the corresponding reference signals are transmittedThe second note, we need to discuss different purpose, it is too restrictive that the RS is counted only once regardless of the purpose, and it is also conflicting with FG16-1g-1 |
| ZTE | Support both notes in principle. For the second note, we think that we need to make it general as follows: Note: If a ~~CSI-RS~~ resource is associated with multiple usages, the ~~CSI-RS~~ resource is only counted one time |
| LG | Same comment as above FGs. General counting issue can be handled by RAN2 and prefer to align across all FGs. |
| Docomo | Support both notes. Also support ZTE’s update on the 2nd note. |
| Intel | Prefer same approach to 16-1g |
| Huawei, HiSilicon  | Support Proposal 3.  |
| vivo | Similar approach should be used for 16-1g and 16-1g-1. |

# Conclusion

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# References

1. R1-2009585, Updated RAN1 UE features list for Rel-16 NR, Moderators (AT&T, NTT DOCOMO, INC.)
2. R1-2100635, Remaining issue on UE features, Intel Corporation
3. R1-2101273, Remaining details of Rel-16 NR UE features, Huawei/HiSilicon
4. R1-2101342, Discussions on NR Rel-16 UE features, Apple
5. R1-2101444, Discussion on NR Rel-16 UE features, Qualcomm Incorporated
6. R1-2101685, Remaining issues on Rel-16 eMIMO UE features, vivo