**3GPP TSG RAN WG1 #107-e R1-2111715**

**e-Meeting, November 11th – 19th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary for multi-beam enhancement

**Document for:** Discussion and Decision

## Introduction

In this summary, the term “item 1” refers to the first item in the Rel.17 NR FeMIMO WID, i.e. multi-beam enhancement:

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| 1. Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:
	1. Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management for intra-cell and inter-cell scenarios to support higher UE speed and/or a larger number of configured TCI states:
		1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA
		2. Unified TCI framework for DL and UL beam indication
		3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)
		4. For inter-cell beam management, a UE can transmit to or receive from only a single cell (i.e. serving cell does not change when beam selection is done). This includes L1-only measurement/reporting (i.e. no L3 impact) and beam indication associated with cell(s) with any Physical Cell ID(s)
			1. The beam indication is based on Rel-17 unified TCI framework
			2. The same beam measurement/reporting mechanism will be reused for inter-cell mTRP
			3. This work shall only consider intra-DU and intra-frequency cases
	2. Identify and specify features to facilitate UL beam selection for UEs equipped with multiple panels, considering UL coverage loss mitigation due to MPE, based on UL beam indication with the unified TCI framework for UL fast panel selection
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This summary includes the following:

* Observation and proposal
* Summary of current companies’ positions on each of the aspects within the category

## Summary of companies’ inputs

### Issue 1 (Rel.17 unified TCI framework – note: for intra-cell beam management unless otherwise noted)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.1 | **Proposal 1.A.1**: On Rel-17 unified TCI framework, any SRS resource or resource set that is a valid target signal of a Rel-15/16 spatial relation based on the Rel-15/16 spatial relation rules (on source-target relations) can be configured as a target signal of a Rel-17 UL or, if applicable, joint TCI (hence the Rel-17 UL or, if applicable, joint TCI state pool).* Note: This does not imply that DL and UL TCI state pools are separate or shared for separate DL/UL TCI (this issue is up to RAN2)

**FL Note**: Discussed offline [1] | **Support/fine**: Sony, Nokia/NSB, Ericsson, Samsung, MTK, Fraunhofer IIS/HHI, CMCC, Futurewei, Intel, vivo, NEC, AT&T, NTT Docomo, QC, CATT**Concern**: OPPO, ZTE, Lenovo/MotM |
| 1.2 | **Proposal 1.A.2**: On Rel-17 unified TCI framework, for any SRS resource or resource set that does not share the same indicated Rel-17 TCI state(s) as dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources, but can be configured as a target signal of a Rel-17 UL or, if applicable, joint TCI (hence the Rel-17 UL or, if applicable, joint TCI state pool), Rel-17 mechanism(s) which reuse the Rel-15/16 spatial relation info update signaling/configuration design(s) are used to update/configure such SRS(s) with Rel-17 UL or, if applicable, joint TCI state(s).* Applies for both intra-cell and inter-cell beam indication
* All the Rel-17 UL or, if applicable, joint TCI states configured to SRS resources in the same set should be associated with the same UL PC setting.

**FL Note**: Discussed offline [1] | **Support/fine**: Sony, Nokia/NSB, Ericsson, Samsung, MTK, Fraunhofer IIS/HHI, CMCC, Futurewei, Intel, NEC, AT&T, NTT Docomo, QC, CATT**Concern**: [OPPO], ZTE, Lenovo/MotM |
| 1.3 | **Proposal 1.A.3**: The UE is not expected to be configured with Rel-15/Rel-16 TCI/SpatialRelationInfo if the UE is configured with Rel-17 TCI in any CC**FL Note**: Discussed offline [1] | **Support/fine**: Nokia/NSB, Ericsson, Samsung, Apple, MTK, Fraunhofer IIS/HHI, CMCC, Futurewei, Intel, vivo, NEC, AT&T, QC, CATT**Concern**: Sony, OPPO, Lenovo/MotM, NTT Docomo |
| 1.4 | **Proposal 1.B**: On Rel.17 unified TCI framework, for Rel-17 unified TCI, when a UE is configured with separate DL/UL TCI, the largest number of configured TCI states for DL TCI state update is 128 per BWP per CC, and the largest number of configured TCI states for UL TCI state update is 64 per BWP per CC* The number of configured TCI states a UE can support is a UE capability (possible values TBD in UE feature session)
* Note: This doesn’t imply that UL TCI shares the same TCI state pool as or uses a different TCI state pool from joint DL/UL TCI

**FL Note**: Already discussed last meeting at length | **Support/fine**: NTT Docomo, Apple, Samsung, ZTE, [Nokia/NSB], Futurewei, [LG], Xiaomi, Fraunhofer IIS/HHI, Sony, Huawei, HiSilicon, Spreadtrum, MTK, Ericsson, AT&T, CMCC, TCL, CATT**Concern**: QC, Apple |
| 1.5 | **Proposal 1.C.1**: On Rel-17 unified TCI framework, after X symbols from the UE receives the BFRR from NW, the UE assumes the same QCL parameter as the ones associated with the index qnew for all UE-dedicated PDSCH/PDCCH receptions in a CC or in a set of configured CCs with common TCI state ID activation and update, as well as other signals/channels configured to sharing the same indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH reception.* Above applies to both Rel-15 SpCell BFR and Rel-16 SCell BFR

**FL Note**: Discussed offline [1], MTK’s version only for DL | **Support/fine**: QC, CATT, NTT Docomo, Samsung**Concern**:  |
| 1.6 | **Proposal 1.C.2**: On Rel-17 unified TCI framework, if the UE is configured with joint DL/UL TCI mode, after X symbols from the UE receives the BFRR from NW, the UE uses the same UL spatial filter as the one associated with the index qnew for all dynamic-grant/configured-grant based PUSCH transmissions and all of dedicated PUCCH resources in a CC or in a set of configured CCs with common TCI state ID activation and update, as well as other signals/channels configured to sharing the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources.* Above applies to both Rel-15 SpCell BFR and Rel-16 SCell BFR
* FFS: UL PC control including qu, qd, and closed loop index

**FL Note**: Discussed offline [1], MTK’s version only for UL | **Support/fine**: QC, NTT Docomo, Samsung**Concern**: |
| 1.7 | **Proposal 1.D**: On Rel-17 unified TCI framework, for [CSI-RS without QCL configuration (e.g. P/SP-CSI-RS except for P-CSI-RS for BM, BFD-RS)], the UE assumes that its QCL is based on the indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH**FL Note**: Need to discuss and clarify what ‘CSI-RS without QCL configuration’ entails (I tend to agree it is ambiguous as many pointed out – I added some examples but I don’t think it resolves the lack of clarity) | **Support/fine**: Nokia/NSB, Ericsson, Apple, CATT**Concern**: Sony, OPPO, Samsung, ZTE, MTK, Lenovo/MotM, CMCC, QC |
| 1.8 | **Proposal 1.E:** On Rel.17 unified TCI framework, for Rel-17 unified TCI, for DL channels/signals that share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH/PDCCH (via Rel-17 MAC-CE/DCI TCI state update), the following option on source RSs and QCL-Types is also supported:* Option 3: CSI-RS for CSI is configured for QCL-TypeA and QCL-TypeD source RS

**FL Note**: It was explained that the so-called “circular” issue is avoided in practice via NW implementation, i.e. NW will not configure the same CSI-RS for CSI both as source and target RSs. | **Support/fine (23)**: Convida, Huawei/HiSi, Ericsson, ZTE, CMCC, Samsung, Sony, Nokia/NSB, Qualcomm, Fraunhofer IIS/HHI, Futurewei, MTK, NTT Docomo, AT&T, Lenovo/MotM, Intel, Xiaomi, CATT, TCL **Concern**: Apple, OPPO  |
| 1.9 | **Proposal 1.F**: On Rel.17 unified TCI framework, after initial access or reconfiguration with sync, the UE assumes a TCI state based on the SSB identified during random access for DL reception and UL transmission until the UE receives beam indication and is indicated a TCI state for the UE-dedicated PDCCH/PDSCH in a CC and, respectively, dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources in a CC.**FL Note**: TCI state assumption between initial access and the first instance of beam indication. This version is a revision of Samsung’s proposal (removing unnecessary/obvious parts) | **Support/fine:** Samsung (for UL follow beam of preamble)**Concern: QC, CATT**, NTT Docomo |
| 1.10 | **Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, when both PL-RS and spatial relation RS in the UL or (if applicable) joint TCI state are not the same [and they are not CSI-RS for BM with repetition ‘ON’], “beam alignment” also pertains to the following events:* The PL-RS is identical to the QCL Type-D source RS or UL spatial relation RS of the spatial relation RS in the UL or (if applicable) joint TCI state
* The QCL Type-D source RS of PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state
* The QCL Type-D source RS of PL-RS is identical to the QCL Type-D source RS or UL spatial relation RS of the spatial relation RS in the UL or (if applicable) joint TCI state

**FL Note:** Any additional event (bullet) doesn’t seem acceptable for a number of companies. Even the above, some still have concern | **Support/fine:** MTK, Convida, Lenovo/MotM, Qualcomm, Samsung, NTT Docomo, CMCC, Nokia/NSB, Futurewei, CATT, Intel (without last bullet from prev), Fraunhofer IIS/HHI, Spreadtrum, TCL**Concern:** ZTE, vivo, OPPO (4th case not included), Ericsson (use case unclear), LG (5th case not included)  |

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 1**
2. **Share more inputs here if needed**
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| Qualcomm | For 1.A.1, supportFor 1.A.2, supportFor 1.A.3, supportFor 1.B, do not support, no need 128 DL TCI to optimize separate DL/UL TCI performance, unless 64 DL TCI and 32 for UL TCI are canadiate values for UE capabilityFor 1.C.1, supportFor 1.C.2, supportFor 1.D, do not support. Withoout QCL means this RS serves as root QCL source like SSB in current specFor 1.E, supportFor 1.F, do not support. This requires the TCI must have SSB as root QCL source RS. We think legacy rule is sufficient, i.e. CORESET follows selected SSB beam, while PUCCH follows Msg3 Tx beam. For 1.G, support  |
| Apple | For 1.A.1 and 1.A.2, we would like to suggest the proposal be more specific as follows to avoid confusion, actually RAN2 only needs to change the title in section 6.1.3.26. In addition, we think this would have some impact on UE capability on number of configured/active TCI counting. So, we suggest this should be an optional UE feature. **Proposal: Support to reuse the MAC CE defined in section 6.1.3.26 in 38.321 for UL/Joint TCI for SRS*** **Above is applied when SRS resource or resource set that does not share the same indicated Rel-17 TCI state(s) as dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources, but can be configured as a target signal of a Rel-17 UL or, if applicable, joint TCI (hence the Rel-17 UL or, if applicable, joint TCI state pool)**
* **This feature is optional**

For 1.A.3: SupportFor 1.B: We share the same concern with QC.For 1.C.1, We do not think we need to differentiate common channel or dedicated channel, since common channel’s beam also failed. Such differentiation would unnecessarility create a case with >1 active TCI.**Proposal 1.C.1**: On Rel-17 unified TCI framework, after X symbols from the UE receives the BFRR from NW, the UE assumes the same QCL parameter as the ones associated with the index qnew for all ~~UE-dedicated~~ PDSCH/PDCCH receptions in a CC or in a set of configured CCs with common TCI state ID activation and update, as well as other signals/channels configured to sharing the same indicated Rel-17 TCI state as ~~UE-dedicated~~ PDSCH/PDCCH reception.* Above applies to both Rel-15 SpCell BFR and Rel-16 SCell BFR

For 1.C.2: There is no dedicated PUCCH for connected mode UE. We suggest the following revision.**Proposal 1.C.2**: On Rel-17 unified TCI framework, if the UE is configured with joint DL/UL TCI mode, after X symbols from the UE receives the BFRR from NW, the UE uses the same UL spatial filter as the one associated with the index qnew for all dynamic-grant/configured-grant based PUSCH transmissions and all of ~~dedicated~~ PUCCH resources in a CC or in a set of configured CCs with common TCI state ID activation and update, as well as other signals/channels configured to sharing the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH and all of ~~dedicated~~ PUCCH resources.* Above applies to both Rel-15 SpCell BFR and Rel-16 SCell BFR
* FFS: UL PC control including qu, qd, and closed loop index

For 1.D: SupportFor 1.E: Do not support. We object this proposal. There is no use case for such configuration.For 1.F: We suggest this proposal could be general for all CBRA procedure. In fact, it should be after CB-PRACH, otherwise, UE cannot detect RAR. We think the “dedicated” should be removed, since if a beam for common channel is indicated, UE needs to follow the indicated beam for common channel reception. So such behavior should be general.**Proposal 1.F**: On Rel.17 unified TCI framework, after transmitting CB-PRACH ~~initial access or reconfiguration with sync~~, the UE assumes ~~a TCI state based on~~ the SSB identified during random access for DL reception and UL transmission until the UE receives beam indication and is indicated a TCI state for the ~~UE-dedicated~~ PDCCH/PDSCH in a CC and, respectively, dynamic-grant/configured-grant based PUSCH and all of ~~dedicated~~ PUCCH resources in a CC.For 1.G: It seems RAN4’s test case would start from the identical case, which should be the most typical case. All the other cases would not be that necessary.  |
| CATT | For proposal 1.A.1, supportFor proposal 1.A.2, supportFor proposal 1.A.3, supportFor proposal 1.B, fine. The values are aligned with what has been supported in Rel-16.For proposal 1.C.1, supportFor proposal 1.C.2, we suggest to delete the condition ‘if the UE is configured with joint DL/UL TCI mode’. For UE configured with separate DL/UL TCI mode, the new beam should also applicable to all the PUCCH/PUSCH.For proposal 1.D, support.For proposal 1.E, support.For proposal1.F, do not support. We share the similar view as QC, i.e. CORESET follows selected SSB beam, while PUCCH follows Msg3 Tx beam. For prosal 1.G, support |
| MediaTek | Proposal 1.A.1: OkayProposal 1.A.2: OkayProposal 1.A.3: Support. Current RAN1 agreements don't prevent to configure both Rel-15/16 DL TCI state pool and Rel-17 DL TCI state pool simultaneously. We see simultaneous configuration will not only causes unnecessary UE memory overhead, but also leads to an ambiguity which TCI state pool should be used. Thus, an explicit agreement is needed to prevent such simultaneous configuration.Proposal 1.B: OkayProposal 1.C.1: SupportProposal 1.C.2: SupportProposal 1.D: Not support. We fail to see the need to introduce such implicit configuration for P/SP CSI-RS, and it may cause additional ambiguities as mentioned by FL. On the other hand, RAN1 already spent much time discussing on the DL channels/signals that “can” share the same indicated Rel-17 TCI state, and RAN1 reached the consensus only for AP CSI-RS for CSI/BM. Why do we need to discuss P/SP CSI-RS again at this final stage? Proposal 1.E: Okay. However, we prefer not to spend time on this issue if RAN1 cannot reach consensus. RAN1 should have conclusion in RAN1#106bis meeting, as indicated by the following agreement.**Agreement** On Rel.17 unified TCI framework, for Rel-17 unified TCI:* For DL channels/signals that do not share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH/PDCCH (via Rel-17 MAC-CE/DCI TCI state update), all the QCL rules defined in section 5.1.5 in 38.214 are supported
	+ Note: For CSI-RS used to provide QCL indication for non-UE dedicated channels, the CSI-RS should only be QCLed with SSB of the same PCID as that from the serving cell
* For DL channels/signals that share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH/PDCCH (via Rel-17 MAC-CE/DCI TCI state update), the following options on source RSs and QCL-Types are supported
	+ Option 1: TRS is configured for QCL-TypeA source RS and CSI-RS for BM is configured for QCL-TypeD source RS
	+ Option 2: TRS is configured for QCL-TypeA and QCL-TypeD source RS
	+ Note: For inter-cell beam management, SSB with PCID different from that from the serving cell can be used as a QCL Type-C/D source RS for CSI-RS for BM and/or TRS
	+ Further discuss and decide in RAN1#106bis-e whether CSI-RS for CSI can be used as a source RS or not, and if so whether some restriction(s) are needed

Proposal 1.F: Okay in principle. We think it is good to define a unified rule for determining the default beam for unified TCI framework. However, current proposal wording is unclear, e.g., why the SSB cannot be directly used as the default QCL assumptions as in Rel-15/16, the random access is initiated by which procedure, and whether such default beam is also applied to other channels/signals that is configured to share the same indicated Rel-17 state? Therefore, we suggest the following re-wording.**Proposal 1.F**: On Rel.17 unified TCI framework, after initial access or Reconfiguration with sync, the UE assumes the same QCL parameters as the ones associated with ~~a TCI state based on~~ the SSB identified during the random access procedure initiated by the initial access or Reconfiguration with sync for UE-dedicated PDSCH/PDCCH, dynamic-grant/configured-grant based PUSCH, and all of dedicated PUCCH resources ~~for DL reception and UL transmission~~ until the UE receives Rel-17 MAC-CE-based and/or DCI-based beam indication and is indicated with a TCI state for the UE-dedicated PDCCH/PDSCH in a CC and, respectively, dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources in a CC.* FFS: Other DL signals/channels configured to sharing the same indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH.
* FFS: Other UL signals/channels configured to sharing the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, and all of dedicated PUCCH resources.

Proposal 1.G: Support.-----------------------------------------------------------------------------------------------------------------------------------------We would like to point out one critical issue in Rel-17 unified that need to be addressed. According to current RAN1 agreements, UE-dedicated PDCCH/PDSCH should always apply the indicated Rel-17 TCI state. Regarding non-UE-dedicated reception on CORESET(s) and the associated PDSCH, NE can configure whether to apply the indicated Rel-17 TCI state via RRC. However, how to reflect this in specification is not clear since the definition of “UE-dedicated PDCCH/PDSCH” and “non-UE-dedicated PDCCH/PDSCH” are too vague. This issue is critical for implementing RAN1 agreements in corresponding specifications by editors. In our view, there are two possible spec implementations according to current agreements, which are provided as follows for discussion.*For Rel-17 unified TCI framework, on applying the indicated Rel-17 TCI state to PDCCH reception and the respective PDSCH reception, down-select from one of the followings for intra-cell BM:* * *Alt1: Per search space set determination*
	+ *For any PDCCH reception associated with an USS set and the respective PDSCH reception, UE always applies the indicated Rel-17 TCI state.*
	+ *For any PDCCH reception associated with a CSS set and the respective PDSCH reception, whether UE to apply the indicated Rel-17 TCI state can be configured per search space set by RRC*
* *Atl2: Per CORESET determination*
	+ *For any PDCCH reception on a CORESET that is associated with only USS set(s) and the respective PDSCH reception, UE always applies the indicated Rel-17 TCI state.*

*For any PDCCH reception on a CORESET that is associated with at least one CSS set and the respective PDSCH reception, whether UE to apply the indicated Rel-17 TCI state can be configured per CORESET by RRC* |
| NTT Docomo | Proposal 1.A.1: SupportProposal 1.A.2: SupportProposal 1.A.3: Not support.FG 23-1-1 (Unified TCI for [intra- and inter-cell] beam management) is [per band] in R1-2110587. It means UE can report Rel.17 TCI in Band#A but not report Rel.17 TCI in Band#B. In that case, based on Proposal 1.A.3, if gNB configure Rel.17 TCI in Band#A, Band#B does not work. Hence, we suggest as:**Proposal 1.A.3**: The UE is not expected to be configured with Rel-15/Rel-16 TCI/SpatialRelationInfo if the UE is configured with Rel-17 TCI in any CC in a band.Proposal 1.B: Support. Rel.15 supports 128 TCI states for PDSCH. If we supports smaller number from Rel.15, it is degradation from Rel.15. For UL, to make system work in 64 SSB operation with the beam correspondence, we believe 64 TCI states should be supported.Proposal 1.A.1: OKProposal 1.A.2: OKProposal 1.A.3: Not support. Proposal 1.C.1: SupportProposal 1.C.2: Support. We think that we also ned to define UL PC contro parameters.Proposal 1.D: We are open to discuss. More clarification is needed.Proposal 1.E: Support.Proposal 1.F: Not support. We shouldn't overwrite RRC-configured TCI state.Proposal 1.G: Support. |
| Samsung | **Proposal 1.A.1**: Support**Proposal 1.A.2:** Support.Just to confirm the understanding, the second sub-bullet is guaranteed by network implementation.**Proposal 1.A.3**: Support**Proposal 1.B**: Support**Proposal 1.C.1**: Support.Add definition of $q\_{new}$: $q\_{new}$ is a candidate beam identified by the UE in set $q\_{1}$. $q\_{1}$ is the set of candidate beams.**Proposal 1.C.2**: SupportAdd definition of $q\_{new}$: $q\_{new}$ is a candidate beam identified by the UE in set $q\_{1}$. $q\_{1}$ is the set of candidate beams.**Proposal 1.D**: Don’t support in current format. CSI-RS should be allowed as root source RS. This seems to be precluded by this proposal.**Proposal 1.E**: OK**Proposal 1.F**: Support. Regarding the concern raised by Qualcomm and CATT, this proposal is not just for the CORESET and the PUCCH, but for all “UE-dedicated” DL and UL channels after initial access. For uplink the spatial domain filter used for preamble is used for uplink channels.We are also fine with the updates proposed by MediaTek, even though we think the two FFS points can be resolved now. The same QCL/spatial filter should be used for the channels that follow the TCI state of “UE-dedicated” channels.We suggest the following updates on top of the version from MediaTek (are also fine to remove the FFS and include the channels/signals in the FFS a following the same TCI state as UE dedicated channels):**Proposal 1.F**: On Rel.17 unified TCI framework, after initial access or Reconfiguration with sync, the UE assumes the same QCL parameters and UL spatial domain filter as the ones associated with ~~a TCI state based on~~ the SSB and preamble identified during the random access procedure initiated by the initial access or Reconfiguration with sync for UE-dedicated PDSCH/PDCCH, Other DL signals/channels configured to sharing the same indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH, dynamic-grant/configured-grant based PUSCH, and all of dedicated PUCCH resources ~~for DL reception and UL transmission~~ until the UE receives Rel-17 MAC-CE-based and/or DCI-based beam indication and is indicated with a TCI state for the UE-dedicated PDCCH/PDSCH in a CC and, respectively, dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources in a CC.* FFS: Other DL signals/channels configured to sharing the same indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH.
* FFS: Other UL signals/channels configured to sharing the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, and all of dedicated PUCCH resources.

**Proposal 1.G:** SupportThe part in square brackets can be removed (~~[and they are not CSI-RS for BM with repetition ‘ON’])~~ |
| Ericsson | Proposal 1.B: Agree with Docomo’s comment: to support DL operation only, we need 128 TCI states. Any separate UL TCI states (that e.g., use SRS) would be needed on top. Although UE features are discussed separately, we could make an exception to agree on candidate values already now.Proposal 1.F: The statement “TCI state based on the SSB” is somewhat unclear. We do not really see what this adds compared to legacy. Samsung’s update seems more accurate, but we still fail to see the difference compared to legacy. |

### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.1 | **Proposal 2.A**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, Rel-15 L1-RSRP reporting format is reused for all SSBRI-RSRP pairs in one L1-RSRP reporting instance, i.e. for K>1, (K-1) 4-bit differential L1-RSRP(s) calculated relative to the reference (absolute) 7-bit L1-RSRP**FL Note: This was discussed in the last meeting at length and during offline [1]** | **Support/fine**: Apple, OPPO, MTK, NTT Docomo, Samsung, LG, Spreadtrum, Qualcomm, Sony, Xiaomi, Nokia/NSB, CATT, Huawei/HiSi, Lenovo/MotM, ZTE**Concern**:  |
|  |  |  |
| 2.2 | **Conclusion 2.B:** On Rel-17 enhancements for inter-cell beam management, on QCL assumption for paging and short message reception after being activated with at least one TCI state associated with PCI different from serving cell, in Rel-17, there is no consensus on requiring the UE to monitor paging and short message associated with the newly indicated TCI state associated with a PCI different from the serving cell.**FL Note: This was discussed in the last meeting at length and during offline [1]**On Rel-17 enhancements for inter-cell beam management, on QCL assumption for paging and short message reception after being activated with [only one] TCI state[(s)] associated with PCI different from serving cell:* Alt0. The UE is not required to monitor paging and short message associated with the newly indicated TCI state associated with a PCI different from the serving cell
* Alt1. The UE is to monitor paging and short message in USS configured for paging and short message with the newly indicated TCI state associated with a PCI different from the serving cell
* Alt2. The UE is to monitor paging and short message in Type2 PDCCH CSS configured for paging and short message with the newly indicated TCI state associated with a PCI different from the serving cell

**Alt0 (default – without any agreement this is the outcome).** * Support: OPPO, vivo, Lenovo/MotM, MTK (2nd), CATT, NTT Docomo, Intel, NEC, Qualcomm
* Concern: Huawei, HiSilicon, Apple

**Alt1**. * Support: Huawei/HiSi (2nd), Ericsson (>=1), Samsung (2nd preference), Spreadtrum, AT&T, Nokia/NSB
* Concern: MTK, OPPO, NTT Docomo, ZTE, Qualcomm

**Alt2**. * **Support/fine:** Huawei/HiSi, Apple, ZTE (>=1), Samsung (>=1), Futurewei, Spreadtrum, AT&T, Sony (>=1), MTK, Xiaomi, CMCC, Nokia/NSB,CATT
* **Concern:** vivo, Lenovo/MotM, LG, Intel, Qualcomm, OPPO
 |
| 2.3 | **Conclusion 2.C:** On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, in Rel-17, there is no consensus on supporting event-driven beam reporting**FL Note**: The latest proposal below from last meeting was discussed at length and concerns still remained**Proposal [2.E]**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, support event-driven beam reporting* If UE consecutively identify an event happens, UE can trigger the L1-RSRP report
* The event at least includes:
	+ The L1-RSRP from one SSB within list of SSBs with PCIs different from serving cell is larger than the best L1-RSRP measured from a list of serving cell SSB plus an offset, where the offset is configured by RRC
	+ The L1-RSRP from one SSB within list of SSBs with PCIs different from serving cell is larger than a pre-defined value which is configured by RRC
	+ The list of serving cell SSBs and SSBs with PCIs different from serving cell are configured by RRC
	+ Indication for activating a reporting configuration
* The L1-RSRP report is transmitted by MAC CE, which includes
	+ SSBRI from the list of SSBs with PCI different from serving cell
	+ L1-RSRP for the corresponding SSB
* A prohibit timer is introduced to prohibit UE sends multiple L1-RSRP report MAC CEs, which is similar to PHR

**Support/fine**: Apple, NTT Docomo, ZTE, Nokia/NSB, Qualcomm, AT&T, Xiaomi, Sony, Huawei, HiSilicon, CATT**Concern**: Futurewei, Intel, LG (concern on MAC CE), MTK, Ericsson, Samsung (concern on MAC CE), OPPO, vivo, Spreadtrum, Lenovo/MotM (remove last bullet)  |

Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 3**
2. **Share more inputs here if needed**
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| Qualcomm | For 2.A, supportFor 2.B, no need for such conclusion. The agreement is already clear, i.e. only UE dedicated PDCCH/PDSCH can be on non-serving PCI. Given this agreement, UE will not receive paging/short message on non-serivng PCI. The agreement also says if gNB wants UE to receive paging, MAC-CE will be used to switch UE back to serving cell. So the issue is already addressed without ambiguity. For 2.C, fine |
| Apple | 2.A: Support2.B: as we discussed in our contribution, we found something is msising in previous agreement. In a certain duration, gNB has to provide 2 TCI states.There can be 3 options to fix this issue:* Option 1: The signals associated with USS and Type 2/3 CSS share the same indicated TCI.
* Option 2: UE does not need to monitor non-UE dedicated signals when a different TCI is indicated for dedicated signals.
* Option 3: Inter-cell BM is only supported for SCell

We think option 1 is aligned with current Alt2. Option 2 is outcome of Alt0. Maybe we can start from option 3. Then we can finalize inter-cell BM for PCell in Rel-18. Current assumption is not fully based on technical aspects, but the key reason is lack of RAN2’s TU.2.C: We think event based beam report is an important aspect. Current BFR cannot support to configure non-serving cell SSB for CBD. Event-based beam report can be helpful for this case. If this is not supported, we suggest the following proposal:**Proposal: Support to configure non-serving cell SSB for candidate beam detection.** |
| CATT | For proposal 2.A, support.For conclusion 2.B, fine. Considering spec impact and flexibility, we are also OK with Alt2.For 2.C. Event-driven reporting has been supported in the L3-based beam measurement and reporting for handover. This feature should be inherited and supported in L1/L2 inter-cell beam measurement and reporting. For event driven reporting, we prefer MAC-CE based event-driven beam reporting considering that the event to trigger the beam reporting is not predictable from gNB side and allocating periodic resource might cause a waste of resources. |
| MediaTek | For 2.A~2.C, support.For 2.C, as mentioned by CATT, L3-based beam measurement and reporting has been supported for handover. However, no cell change is allowed by Rel-17 inter-cell BM. We suggest to leave it to Rel-18 mobility enhancement.---------------------------------------------------------------------------------------------------------------------------------We would like to point out one critical issue in Rel-17 unified that need to be addressed. According to current RAN1 agreements, it is still unclear how to configure SSBs with PCID(s) different from the serving cell in L1-RSRP measurement and reporting. In our view, a CMR resource set can include all the SSBs with the same or different PCIDs, where both of the SSB-indexes and the associated PCIDs should be included in such CMR resource set. Then, UE can directly report the selected SSBs within the configured CMR resource set thought the SSBRIs in the L1-RSRP reporting instance, as in Rel-15/16 L1-RSRP reporting.*Issue 2.4: Configuration and reporting of SSBs with PCID(s) different from the serving cell in L1-RSRP measurement and reporting* |
| NTT Docomo | Proposal 2.A:SupportConclusion 2.B: Not support. We should make clear agreement that “UE monitor/receive paging and short message from serving cell only”. We should be informed to RAN2, because this reply was pending.Conclusion 2.C: Fine, considering the limitted remaining time. Technically, we believe event trigger beam reporting is quite benefitial. |
| Samsung | **Proposal 2.A**: Support**Conclusion 2.B**: While the conclusion is stating a fact that there is “no consensus”, we think that receiving paging and short messages on serving cell, when the UE-dedicated messages are being received on a cell with a PCI different from the PCI of the serving is sub-optimal for performance. If the majority is supporting Alt0, we can accept for progress.**Conclusion 2.C**: OKWhile we would have liked a different outcome, given that this is the last meeting, this seems to be the most expedient option. |
| Ericsson | On conclusion 2.B: If we cannot reach consensus on this, alt0 will be the outcome, and so be it. However, there are some arguments that do not seem accurate:* We have not agreed what “non-UE-dedicated reception on CORESET(s) and the associated PDSCH” is, and we have not agreed that it is based on RNTI, which we think would be somewhat non intuitive.
* There is no RAN2 impact of this – this is all in RAN1’s domain. When I asked RAN2 why P-RNTI cannot be monitored in USS, they answered “Ask RAN1”
* The spec impact of alt2 is very limited: the only thing that is necessary is to add P-RNTI to the RNTIs that are monitored in USS. (Implementation impact is of course another matter, but hopefully it is small)

Both alt1 and alt2 propose to reduce the UE complexity. Alt0 will simply lead to higher requirements on the UE. |
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### Issue 3 (signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** |
| 3.1 | The number of BAT values a UE can be configured with (per CC/BWP):* Alt1. One
* Alt2. Two for MPUE
	+ BAT1 for beam switching within the same panel
	+ BAT2 for beam switching across different panels where both panels are activated
 | **Alt1**: Ericcson, OPPO, QC, NTT Docomo**Alt2**: Samsung, CATT**Alt3**: MTK (two for beam switching between different cells) |
| 3.2 | Further enhancements on ACK/NAK for DCI formats 1\_1/1\_2 with DL assignment when used for beam indication  | **DCI ACK/NAK:** CATT, Apple, Xiaomi, Samsung, Intel (with higher priority for beam indication DCI ACK/NACK), ASUSTek**DL assignment ACK/NAK, but only ACK can be used to confirm beam indication:** NEC, OPPO, NTT Docomo (already agreed), Huawei. HiSilicon, Xiaomi, QC  |
| 3.3 | Support for additional beam indication scheme for Rel-17 unified TCI framework beyond agreement to-date | **No additional beam indication scheme is supported:** CATT, Samsung, Ericsson, Spreadtrum, CMCC**DCI formats 0\_1/0\_2 with UL grant (for UL-only TCI of separate DL/UL TCI)**: IDC, LG, Sony, MTK, Intel, Xiaomi, TCL, Qualcomm, NEC**New dedicated DCI format for beam indication**: **Group-common DCI**: Sony, Intel, MTK, NTT Docomo, Qualcomm**When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied**: Huawei/HiSi, vivo (until DCI is indicated), Convida (after MAC CE activation), MTK (until DCI is indicated, only for the case if the currently applied TCI state is not one of the activated TCI states), NTT Docomo, NEC |
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Table 6 Additional inputs: issue 3

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 5**
2. **Share more inputs here if needed**
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| Qualcomm | For 3.1, support Alt1For 3.2, reusing PDSCH ACK is sufficient. If NACK, gNB can just retransmit for the worst case. Scheduled PDSCH BLER should be controlled to be low anywayFor 3.3, support UL grant also indicating unified TCI, and group common DCI to reduce DCI overhead |
| Apple | 3.1: This depends on the outcome of issue 4. We are not sure whether there is still enough time to finish issue 4. But if issue 4 is supported, we think 2 action delay should be considered.3.2: We think it is more reasonable to use ACK/NACK for DCI since usually the link budget for PDSCH is not as good as PDCCH.3.3: We failed to see the necessity for this. But one thing we would like to clarify, is it correct understanding that UE should ignore the TCI indicated in DCI without data for other purposes, e.g. SPS-release? |
| CATT | For issue 3.1, support Alt2. Due to panel activation, BAT should be larger for beam switching across panels.For issue 3.2, support ACK/NACK for DCI. As PDSCH is less robust than PDCCH, if only ACK is allowed to confirm beam indication, the probability of beam indidcation restransmission will be higher.For issue 3.3, there is no need to introduce additional beam indication scheme. The current supported scheme would work. |
| MediaTek | For 3.1, considering NW is not able to differentiate whether the TCI state update will trigger panel switching even RAN1 has any progress in Issue 4, we prefer to have one BAT for MP-UE. However, DCI-based beam switching between different cells is possible for inter-cell BM, and UE may require additional latency when it switches between different cells. Therefore, for inter-cell beam indication, UE can report an additional capability with a larger value of minimum application time.For 3.2, these optimizations are not necessary. |
| NTT Docomo | Issue 3.1: We think Alt.1 (One) is default, unless we make additional agreement.Issue 3.2: We have concern to include "NACK", because the NACK to ACK error probability is 1%. On the other hand, ACK to NACK error probability is 0.1%. If the miss-understanding of the acknowledgement happens at gNB, serious beam miss alignment issue happens. This is why Y-symbol is agreed to be counted after the acknowledgement (not DCI). Also, in our understanding, "after ACK" is already agreed, and we don’t need to discuss this. Question to supporters of ACK/NACK of DCI: why we define Y-symbol from the acknowledgement? We believe it is to avoid the beam miss alignment issue. If we include NACK as the acknowledgement, there is no benefit to count Y-symbol from the acknowledgement, from reliability perspective. The miss detection probability of DCI is usually 1%, and NACK to ACK error probability is also 1%.Rather than this issue, we should discuss how to select the beam indication DCI, if multiple ACK are transmitted in a PUCCH/PUSCH.Issue 3.3: Considering the limited remaining time, we are fine with no additional beam indication scheme in Rel.17. |
| Samsung | **Issue 3.1**: Support Alt2 (pending the outcome of issue 4).**Issue 3.2**: Both ACK/NACK can be used when there is no ambiguity between NACK and DTX.To address the comment from NTT Docomo, as to why the BAT is from the HARQ-ACK feedback and not from the DCI in case of a NACK. When sending PDCCH/PDSCH to the UE, there are three possible outcomes:* PDCCH not received 🡺 DTX
* PDCCH is received by PDSCH is not successfully decoded 🡺 NACK
* PDCCH is received and PDSCH is successfully decoded 🡺 ACK

If the PDCCH is received whether the PDSCH is successfully decoded or not, the UE can apply the indicated beam, the network doesn’t know if the PDCCH is received until it gets the HARQ-ACK, hence the BAT is always from the HARQ-ACK feedback.**Issue 3.3**: There are many good ideas for additional beam indication mechanisms that enhance the performance of beam indication. But alas! We are at the last meeting of Rel-17 and there is little time to introduce additional beam indication schemes. |
| Ericsson | Issue 3.1: After checking with RAN4 colleagues, I’ve understood that RAN4 cannot design tests for the two scenarios (same/different panels). Therefore, there would seem to be no point in agreeing to two BATs in RAN1.Issue 3.2: For the proposal “DL assignment ACK/NAK, but only ACK can be used to confirm beam indication”, this is up to NW implementation. (The proposal seems like a reasonable way to implement it.) |
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### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** |
| 4.1 | **Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, * Support the UE reporting a list of UE capability value sets
	+ Each UE capability value set comprises at least the max supported number of SRS ports
	+ [No two value sets can have identical entries]
	+ FFS: which type(s) of UE capability other than the max supported number of SRS ports is included in a UE capability value set and whether the UE capability value set can be common across all BWPs/CCs in same band or BC are discussed under UE feature agenda item
* The correspondence between a CSI-RS and/or SSB resource index and one of the UE capability value sets in the reported list is determined by the UE (analogous to Rel-15/16) and is informed to NW in a beam reporting instance.
	+ The Rel-15/16 beam reporting is reused, i.e. the index of corresponding UE capability value set is reported along with the pair of SSBRI/CRI and L1-RSRP/SINR (up to 4 pairs, with 7-bit absolute and 4-bit differential) in the beam reporting UCI
* Support multiple codebook-based SRS resource sets with different number of SRS ports
	+ ~~The indicated SRI is based on the SRS resources corresponding to a selected SRS resource set [which need to be aligned with the UE capability based on the informed correspondence]~~
	+ FFS: Decide in RAN1#107e, whether the SRS resource set is selected by the UE or NW

**FL Note: Discussed offline at length [1]. I removed the sub-bullet of 3rd bullet since it is not proper to define NW behavior. Added red text in brackets to address Ericsson’s concern** | **Support**: InterDigital, ZTE, Sony, Xiaomi, Lenovo/MotM, Fraunhofer IIS/HHI, Nokia/NSB, AT&T, Samsung, MediaTek, QC**Concern**: OPPO, Ericsson (need to add red text in 1st bullet), Intel (1st and 3rd bullets), Apple, CATT |

Table 8 Additional inputs: issue 4

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 5**
2. **Share more inputs here if needed**
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| Qualcomm | For 4.A, support and also fine for the red text in 1st bullet |
| Apple | We think there is not enough time to finish all aspects for panel selection in R17. One way is to finish the report related aspects, and let the gNB configuration part open – any gNB configuration that follows the UE capability should be fine. From gNB side, it can either use RRC reconfiguration, or BWP switching or any other ways to update the configuration to follow the UE capability. We can optimize the gNB signaling in R18. So we suggest we start from the following proposal from our comments in the offline discussion.**Proposal: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,** * **Support the UE reporting a list of non-repeated UE capability values**
	+ **Each UE capability value set comprises at least the max supported number of SRS ports**
* **The correspondence between a CSI-RS and/or SSB resource index and one of the UE capability value sets in the reported list is determined by the UE (analogous to Rel-15/16) and is informed to NW in a reporting instance.**
	+ **The reporting may be either periodic or triggered by a certain event.**
	+ **FFS: details for the reporting**
* **For each indicated TCI state, the corresponding configuration, e.g. number of ports for each SRS resource, should follow the latest reported UE capability**
	+ **How to provide the configuration is up to gNB implementation**
 |
| MediaTek | For 4.A, for progress, we are fine with the red text in brackets. |
| NTT Docomo | Support. We are fine to have the red text in the 1st bullet.And we would like to share our views on the FFS under the last bullet. In our understanding, if UE may only activate panel corresponding to **one** SRS resource set at a time, then we agree the SRS resource set is selected by UE as well as the activated panel is selected by UE, and in this case the selection needs to be known by NW so that NW can indicate SRI. However, if UE may activate panels corresponding to **multiple** SRS resource sets, then we think the SRS resource set can be selected by NW similar as SRI is selected by NW in legacy procedure. |
| Samsung | **Proposal 4.A**: Support |
| Ericsson | As Apple writes, time is short. To clarify also the final FFS, we propose the following modification:**Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, * Support the UE reporting a list of UE capability value sets
	+ Each UE capability value set comprises at least the max supported number of SRS ports
	+ [No two value sets can have identical entries]
	+ FFS: which type(s) of UE capability other than the max supported number of SRS ports is included in a UE capability value set and whether the UE capability value set can be common across all BWPs/CCs in same band or BC are discussed under UE feature agenda item
* The correspondence between a CSI-RS and/or SSB resource index and one of the UE capability value sets in the reported list is determined by the UE (analogous to Rel-15/16) and is informed to NW in a beam reporting instance.
	+ The Rel-15/16 beam reporting is reused, i.e. the index of corresponding UE capability value set is reported along with the pair of SSBRI/CRI and L1-RSRP/SINR (up to 4 pairs, with 7-bit absolute and 4-bit differential) in the beam reporting UCI
* Support ~~multiple codebook-based~~ SRS resource set~~s~~ with usage ‘codebook’ with different number of SRS ports
	+ ~~The indicated SRI is based on the SRS resources corresponding to a selected SRS resource set [which need to be aligned with the UE capability based on the informed correspondence]~~
	+ ~~FFS: Decide in RAN1#107e, whether the SRS resource set is selected by the UE or NW~~

This would complete the functionality, increase the NW flexibility, and would also mirror the type of functionality of UL full-power transmission. |
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### Issue 5 (MPE)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** |
| 5.1 | On Rel.17 enhancements to facilitate MPE mitigation, the selection of N from a candidate SSB/CSI-RS resource pool: * Alt1. Based on L1-RSRP minus P-MPR value for each resource
* Alt2. No RAN1 spec impact (possibly left to RAN4)
* Alt3: Based on modified vPHR (with per beam PMPR and PL) for each resource.
 | Alt1:* **Support**: Ericsson, Samsung, LG, Qualcomm, Spreadtrum, Xiaomi, IDC, Sony
* **Concern**: vivo, OPPO, Apple

Alt2: * **Support**: vivo, Intel, OPPO, Apple
* **Concern**:

Alt3: * **Support**: NTT Docomo
* **Concern**:
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Table 10 Additional inputs: issue 5

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 5**
2. **Share more inputs here if needed**
 |
| Qualcomm | Support Alt1 to have aligned understanding between gNB and UE |
| Apple | We do not support to define additional scheme for beam selection. We can be open for gNB to update the candidate SSB/CSI-RS resource pool based on some L1/L2 signaling. But which beam to be reported should be up to UE implementation.In addition, we think for MPE related issue, a more important aspect is the triggering condition. Now P-MPR is defined in beam level, legacy trigger condition is unclear. |
| MediaTek | We are fine to leave it as UE implementation. In one example, UE can report L1-RSRP values in L1-RSRP reporting and P-MPR values in P-MPR reporting, respectively, for the same set of SSBRIs/CRIs, if both L1-RSRP reporting and P-MPR reporting are associated with the same SSB/CSI-RS resource set. Then, NW can perform UL beam selection based on the two information. However, in order to make sure that UE can perform measurement on the same set of RS resources and report the SSBRIs/CRIs for L1-RSRP/SINR and P-MPR reporting, the SSB/CSI-RS resource set associated with P-MPR reporting should be also associated with L1-RSRP/SINR reporting. |
| NTT Docomo | We think the selection rule should be defined. So, we donot support Alt2.But Alt1 may be not good since the beam with best L1-RSRP minus P-MPR may not be the beam with best UL RSRP, considering L1-RSRP also depends on DL Tx power. Hence, we prefer to use modified vPHR (with per beam PMPR and PL) to select the best UL beams because modified vPHR can represent UL Tx power – PL. We suggest adding following Alt3.Alt3: Based on modified vPHR (with per beam PMPR and PL) for each resource. |
| Samsung | Support Alt1 |
| Ericsson | We find it strange that the beam selection would be up to UE implementation. We also noted that there are statements that the Rel-15 specification does indicate that the UE should report the highest RSRP values. With that interpretation, there is no need to define any new P-MPR reporting: the UE could simply report the best UL beams also in the Rel-15 DL RSRP report.  |
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# References

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| 1 | R1-2111716 | Summary of offline discussion on unified TCI, inter-cell beam management, and MPUE | Moderator (Samsung) |