**3GPP TSG RAN WG1 #106-e R1-210xxxx**

**e-Meeting, August 16th – 27th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#6 for multi-beam enhancement: ROUND 5

**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
 |

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

The listed issues are structured primarily to facilitate some progress on pending issues identified in the agreements (see Appendix A).

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

(no more for this meeting)

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

**Proposal 2.E**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, select NMAX (the maximum number of RRC configured TRP(s) with different PCIs from the serving cell for measurement/reporting) from the following alternatives (to be decided in RAN1#106bis-e):

* Alt1: NMAX is up to UE capability with candidate values of 1 and X.
	+ Note: X as agreed in AI 8.1.2.2
	+ When NMAX is configured to be X, the UE measures up to X PCIs different from the serving cell PCI
* Alt2. NMAX  = 1

Table 1 Additional inputs: FL proposal

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Share your inputs on the above FL proposal** |
| MediaTek | Support the proposal |
| Ericsson | Support Alt1. Maybe we can add a note **Proposal 2.E**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, select NMAX (the maximum number of RRC configured TRP(s) with different PCIs from the serving cell for measurement/reporting) from the following alternatives (to be decided in RAN1#106bis-e): * Alt1: NMAX is up to UE capability with candidate values of 1 and X.
	+ Note: X as agreed in AI 8.1.2.2
	+ When NMAX is configured to be X, the UE measures up to X PCIs different from the serving cell PCI
	+ Additional restrictions may be added by RAN4
 |
| Sony | It looks fine to us.  |
| Apple | OK with majority as long as UE can report Nmax = 1 and smaller value than X.  |
| Nokia/NSB | TRP is not visible in the specifications. We propose the following update:**Proposal 2.E**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, select NMAX (the maximum number of RRC configured ~~TRP(s)~~ reference signals with different PCIs for L1-RSRP measurements/reporting from the serving cell for measurement/reporting) from the following alternatives (to be decided in RAN1#106bis-e): * Alt1: NMAX is up to UE capability with candidate values of 1 and 2.
	+ When NMAX is configured to be 2, the UE measures up to 2 PCIs different from the serving cell PCI
* Alt2. NMAX  = 1

**Alt2. (for R17) but the specified solution should not prevent any later extensions to the max number of different PCIs to be support.** |
| LG | Support the proposal. Either Alt1 or Alt2 is fine to us. |
| ZTE | Support the proposal and we prefer Alt1. Regarding Nokia’s update, it seems to change the intention of this bullet to ‘maximum number of non-serving cell RS to be measured’. Instead, we focus the maximum number of non-serving cell (e.g., TRP(s) with different PCSI from serving cell). |
| NTT Docomo | Support the proposal. We support Alt.1. |
| CATT | Support the proposal |
| Xiaomi | Support the proposal |
| InterDigital | Support the proposal |
| Samsung | Support |
| OPPO | Ok |
| CMCC | Support the proposal |
| vivo | OK. Nokia’s update seems not correct. |
|  |  |

### Issue 3 (beam indication signaling medium)

(no more for this meeting)

### Issue 4 (MP-UE)

Table 2 Summary: issue 4

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| --- | --- |
| Proposal 4.A V2 | **Support/ok**: LG, Sony, Samsung, Lenovo/MotM, Qualcomm, Apple, MTK, ZTE, IDC, LG, CMCC, vivo, NTT Docomo, Spreadtrum, Xiaomi, Fraunhofer IIS/HHI**Concern**: Ericsson, OPPO, CATT, Nokia/NSB |
| Proposal 4.A V3 (proposed by Ericsson during GTW)  | **Support/ok**: Ericsson**Concern**:  |

**Proposal 4.A V2**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:

* A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
	+ The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW
		- FFS: Detailed design of how to inform the correspondence to NW
	+ Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16)
* Support UE reports maximum number of SRS ports for each panel entity
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ The indicated SRI is based on the SRS resources corresponding to one SRS resource set, where the SRS resource set should be aligned with the UE capability for the panel entity

**OR**

**Proposal 4.A V3**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:

* Include in the CSI report, the maximum number of supported number of SRS antenna ports corresponding to the reported SSBRI/CRI
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ The indicated SRI is based on the SRS resources corresponding to one SRS resource set, where the SRS resource set should be aligned with the UE capability for the panel entity

Table 3 Additional inputs: issue 4

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 2 based on the two alternative proposals (4.A V2 vs 4.A V3).****2) Summarize your concern, if any, on a proposal you are against**  |
| MediaTek | We prefer Proposal 4.A V2 with minor change to align the second and third bullets.**Proposal 4.A V2**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:* A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
	+ The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW
		- FFS: Detailed design of how to inform the correspondence to NW
	+ Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16)
* Support UE reports maximum number of SRS ports for each panel entity as a UE capability
* Support multiple codebook-based SRS resource sets with different number of SRS ports
	+ The indicated SRI is based on the SRS resources corresponding to one SRS resource set, where the SRS resource set should be aligned with the UE capability for the panel entity

On Proposal 4.A V3, we believe the itension of this proposal is the same as the one of V2. However, V2 captures the whole procedure to support UL MIMO layer adaptation more clearly. For example, it is unclear in V3 how NW can configure the SRS resource sets with propoer number of SRS ports that UE can support before UE reports the maximum number of supported SRS ports through the beam reporting. |
| Ericsson | For V3, we prefer that the UE reports the max UL rank.Concerns on V2:Introduction of panel ID may lead to panel-centric UE handling.It is unclear how the correspondence is reported to the NWThe extension to FR1 is unclearThe separate mapping between the panel ID and rank leads to additional delayTo MTek: either method relies on the first report to determine the rank. |
| Sony | Support Proposal 4.A V2. In V2, we think the correspondence (potentially dynamic) between UE panel and CSI-RS/SSB is conveyed by beam reporting, it doesn’t rely on how many antenna ports CB-based SRS resources can apply. So we are fine with MTK’s revision on the second bullet by adding “as a UE capability”. As for V3, we try to understand it as that the maximum number of supported SRS antenna ports is used to identify an UE antenna panel entity. One quick comment popped up in mind is that what if UE reports the same number of maximum SRS antenna ports from two UE panels, how would gNB to tell which panel corresponding to which SRS antenna ports for UL transmission? Perhaps a rule for gNB to interpret UE beam reporting is needed.  |
| Apple | Our first preference is V2, and we can also accept V3. Both V2 and V3 can be supported for both FR1 and FR2. We can change the term “panel entity” into a logical name like “transmission process”. The word “panel” may give people a wrong impression that this can only be supported for FR2.@Ericsson, For V3, it should be number of port instead of max UL rank. If we assume different number of ports in different panels. For example, if UE report max\_rank = 1 for SSB1 and max\_rank = 2 for SSB2, gNB may still schedule a transmission from a 2 Tx codebook with rank 1 precoder when SSB1 is used for beam indication. |
| Nokia/NSB | We would ok in principle with Proposal 4.A V3 with the following update (UE’s maximum number of ports may be indexed). Prefer also to delete the last reference to panel entity.**Proposal 4.A V3**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:* Include in the CSI report, the maximum number of supported number of SRS antenna ports or an index value corresponding the maximum number of supported number of SRS antenna ports corresponding to the reported SSBRI/CRI
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ ~~The indicated SRI is based on the SRS resources corresponding to one SRS resource set, where the SRS resource set should be aligned with the UE capability for the panel entity~~
 |
| LG | We will not object V3 if other companies are OK with this direction but we prefer V2 since it is applicable for both heterogeneous panel and homogeneous panel cases. |
| ZTE | We support V2, and have some questions on V3 for clarification.Regarding some companies’ comments on V2, I provide the following replies based on our understanding:* Firstly, UE-initialized panel activation has been agreed before, and we have to accept panel-centric UE handling;
* Secondly, why we need to consider FR1? The scenario/usage of FR1 UE multi-panel operation is unclear to us;
* Thirdly, we agree that the separate mapping between the panel ID and rank leads to additional delay. So, we can accept your following bullet as an additional bullet in V2.
	+ Include in the CSI report, the maximum number of supported ~~number of SRS antenna ports~~ max UL rank corresponding to the reported SSBRI/CRI

Then, we have the following comments on V3 for clarification* Whether an additional index is needed for representing entity corresponding a specific maximum number for SRS ports, a given port group or a transmission process? It seems that E/// want to preclude it but Apple and Nokia suggests to have it.
* Then, if having the index, can we assume that ‘the index’ is a specific flag corresponding to ‘the correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW’ in V2
* Finally, CSI report refers to L1-RSRP beam report? If so, what’s the relationship between this kind of report and group based report that has been specified in Rel-15/16 and enhanced in Rel-17.

Generally speaking, based on the fact that we only have two meetings left and there is a very short gap between last two meetings, we prefer to make down-selection ASAP. |
| Xiaomi | Prefer V2.  |
| Ericsson | Answer to Sony: The NW does not have to know the panel: it is enough that the NW know the relevant properties of the transmission of the panel – in this case the number of layers.We are also OK with Nokia’s update.To LG: we were thinking that this would be applicable to any heterogenous panel layouts as well. What limitation do you see in this aspect?To ZTE: * our concern is that it will lead to NW-controlled panel handling.
* The functionality would be applicable to FR1 also, if the UE for instance wants to reduce the number of UL layers to reduce power consumption.
* The point is that the reported max UL rank provides information about the max UL rank – nothing more. As soon as we introduce a new entity, there will be interpretations what it will be used for. That is why we propose to report something that is already clearly defined.
 |
| InterDigital | Our first preference is V2, and we can also accept the direction of V3 if agreeable.We share similar view as ZTE. If the term of “panel entity” is somewhat sensitive to a company, we may really consider to have another term like “port group” or “transmission process”, etc., although the group should remind that the panel entity is already a logical term in the specification perspective.We also share Sony’s question as valid in the case of ‘the same number of maximum SRS antenna ports from two UE panels’ for V3 which has a limitation to work only the heterogeneous panel case as LG mentioned, whereas V2 supports both heterogeneous panel and homogeneous panel cases. But, we can live with the limitation on V3, if agreeable, for the progress. |
| Samsung | Support V2, Concerns with V3* It is unclear how it will work for panel selection/activation. How the maximum number of supported number of SRS antenna ports maps to panel?
* How does it work for the case when the two panels can support same number of max MIMO layers? It seems to restrict to the case when panels can support different number of max MIMO layers.
* It can not be extended to SMPTx. We prefer a solution that works and is stepping stone for SMPTx.

Since this is a beam report, what is the max value for “the number of supported number of SRS antenna ports”? |
| OPPO | We prefer V3. Because the first bullet of V2 suggests to introduce some kind of panel ID, which is not needed according to our analysis.If can not reach a consensus, we would suggest to agree on the **Common Bullet** of V2 and V3 for now. The common bullet is the main design in both proposals from our understanding. Similar to Nokia, we also prefer a minor wording changing here and delete the “panel entity” in this common part. **Common Bullet of V2 and V3 with slight wording change**:* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ The indicated SRI is based on the SRS resources corresponding to one SRS resource set, where the SRS resource set should be aligned with the UE capability ~~for the panel entity~~
 |
| MediaTek | We still feel there is a common ground between V2 and V3. Hope the following proposal could work.**Proposal 4.A VX**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:* Support UE reports the maximum number of supported index values as a UE capability
* NW can configure a set of index values based on UE capability, and associate one of the followings with each configured index value:
	+ Alt1: The max number of supported SRS antenna ports corresponding to a reported SSBRI/CRI
	+ Alt2: The max number of supported UL MIMO layers corresponding to a reported SSBRI/CRI
* Include a configured index value corresponding to a reported SSBRI/CRI in a beam reporting instance
	+ Note: the correspondence between a SSBRI/CRI and an index value is determined by the UE
* Support multiple codebook-based SRS resource sets with different number of SRS antenna ports

According to comments from E///, Nokia, and OPPO, NW can configured multiple index values and each index value associated with different number of supported UL MIMO layers corresponding to a reported SSBRI/CRI. Then, UE can feedback one of the configured index values along with each SSBRI/CRI in the beam report, based on NW configuration.According to comments from most companies, the index value can be used as the correspondence between a panel entity and a reported SSBRI/CRI. Corresponding to a reported SSBRI/CRI, whether the max number of supported SRS antenna ports or the max number of supported UL MIMO layers should be used can be further discussed in the next meeting.  |
| CMCC | Support V2. MTK’s version is also fine to us.  |
| vivo | We prefer Alt2. And we don’t think number of layers/SRS ports is the only aspect related to panels. Thus Alt3 seems too limited.  |
|  |  |

### Issue 5 (MPE mitigation)

(no more for this meeting)

### Issue 6 (advanced beam refinement/tracking)

**Proposal 6.A**: On Rel-17 enhancements to facilitate advanced beam refinement/tracking, in Rel-17, further focus study (including down-selection) and, if needed, specification effort on Opt 1-A as agreed in RAN1#105-e (UE-initiated beam selection/activation based on beam measurement and/or reporting, without beam indication or activation from NW) comprising:

* UE-initiated (DL-only or DL/UL) beam selection, including the following options
	+ Opt1. The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, PRACH, UL CG, or CBRA/CFRA
	+ Opt2. The selected beam is reported by a legacy UE beam report (NW-configured)
	+ FFS on NW-indication of a beam group in which the UE is allowed to do the beam selection, e.g., the NW-indication via MAC-CE
* UE-initiated beam activation based on beam reporting
	+ The reported beam(s) are activated as active TCI/spatial relation RS(s) automatically w/o NW activation command after receiving gNB response ignalling
	+ FFS: The reported beam is applied directly if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling
* UE-initiated UL-only beam selection
	+ The UE can select an alternative beam from the other beams in the gNB-configured set containing more than one UL beam

Table 4 Summary: issue 6

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| Proposal 6.A | **Support/ok**: ZTE, Qualcomm, Samsung, Apple, IDC, LG, NTT Docomo, CATT, MTK, **Concern**: Ericsson |

Table 5 Additional inputs: issue 6

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| **Company** | **Input** |
| Mod V0 | **1) Update table 4 if needed****2) Please share your inputs, if any, on proposal 6.A** |
| MediaTek | Support the proposal |
| Apple | Support |
| Nokia/NSB | Support |
| LG | Support the proposal |
| ZTE | Support. A minor update for the following bullet for making it clear.* UE-initiated beam activation based on beam reporting
	+ The reported beam(s) are activated as active TCI/spatial relation RS(s) automatically w/o NW activation command after receiving gNB response ignalling, e.g., DCI/MAC-CE
	+ FFS: The reported beam is applied directly if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling
 |
| NTT Docomo | Support the proposal. We are fine with ZTE’s modification. |
| CATT | Support |
| InterDigital | Support |
| Samsung | Support with the following changes* + Opt1. The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, ~~PRACH~~, UL CG, or Type 1/Type 2 CBRA/CFRA

PRACH is redundant with CBRA/CFRAType 1/Type 2 refers to 4 step and 2-step RACH respectively.Fix typo in “5ignalling” |
| vivo | It seems the work would be large for any one of the following.If the majority would like to have this further study, we would like to update as following:**Proposal 6.A**: On Rel-17 enhancements to facilitate advanced beam refinement/tracking, in Rel-17, further focus study (including down-selection) and, if needed, specification effort on Opt 1-A as agreed in RAN1#105-e (UE-initiated beam selection/activation based on beam measurement and/or reporting, without beam indication or activation from NW) comprising: * UE-initiated (DL-only or DL/UL) beam selection, including the following options
	+ Opt1. The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, PRACH, UL CG, or CBRA/CFRA
	+ Opt2. The selected beam is reported by a legacy UE beam report (NW-configured)
	+ FFS on tiggered condition and NW-indication of a beam group in which the UE is allowed to do the beam selection, e.g., the NW-indication via MAC-CE
* UE-initiated beam activation based on beam reporting
	+ The reported beam(s) are activated as active TCI/spatial relation RS(s) automatically w/o NW activation command after receiving gNB response ignalling
	+ FFS: The reported beam is applied directly if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling
* UE-initiated UL-only beam selection considering potential mis-alignment between network and UE on the selected beams
	+ The UE can select an alternative beam from the other beams in the gNB-configured set containing more than one UL beam
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# References

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| --- | --- | --- | --- |
| 1 | R1-2106864 | Summary of offline discussion on unified TCI and inter-cell beam management | Moderator (Samsung) |
| 2 | R1-2106463 | Enhancements on multi-beam operation in Rel-17 | Huawei, HiSilicon |
| 3 | R1-2106541 | Enhancements on Multi-beam Operation | ZTE |
| 4 | R1-2106571 | Further discussion on multi beam enhancement | vivo |
| 5 | R1-2106640 | Remaining Details on Enhancements for Multi-beam Operation | IDC, Inc. |
| 6 | R1-2106666 | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
| 7 | R1-2106685 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
| 8 | R1-2106789 | Further enhancement on multi-beam operation | Sony |
| 9 | R1-2106864 | Moderator summary for multi-beam enhancement | Moderator (Samsung) |
| 10 | R1-2106865 | Multi-Beam Enhancements | Samsung |
| 11 | R1-2106935 | Discussions on enhancements on multi-beam operation | CATT |
| 12 | R1-2107029 | Enhancements on Multi-beam Operation | Fujitsu |
| 13 | R1-2107085 | Enhancement on multi-beam operation | FUTUREWEI |
| 14 | R1-2107143 | Discussion on multi-beam operation | NEC |
| 15 | R1-2107203 | Enhancements on Multi-beam Operation | OPPO |
| 16 | R1-2107297 | Discussion of enhancements on multi-beam operation | FGI, Asia Pacific Telecom |
| 17 | R1-2107323 | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
| 18 | R1-2107390 | Enhancements on multi-beam operation | CMCC |
| 19 | R1-2107464 | Enhancements on multi-beam operation | Fraunhofer IIS, Fraunhofer HHI |
| 20 | R1-2107485 | Enhancement on multi-beam operation | MTK Inc. |
| 21 | R1-2107570 | Enhancements to Multi-Beam Operations | Intel Corporation |
| 22 | R1-2107628 | Enhancements on Multi-beam Operation | Ericsson |
| 23 | R1-2107689 | Enhancements on Multi-beam operations | AT&T |
| 24 | R1-2107718 | Views on Rel-17 Beam Management enhancement | Apple |
| 25 | R1-2107814 | Enhancements on Multi-beam Operation | LG Electronics |
| 26 | R1-2107838 | Discussion on multi-beam operation | NTT DOCOMO, INC. |
| 27 | R1-2107893 | Enhancements on multi-beam operation | Xiaomi |
| 28 | R1-2108019 | Enhancements on Multi-beam Operation | Convida Wireless |
| 29 | R1-2108052 | Enhancements on Multi-beam Operation | Nokia, Nokia Shanghai Bell |
| 30 | R1-2106548 | Further details on Multi-beam and Multi-TRP operation | ZTE |
| 31 | R1-2106671 | HARQ feedback of SPS PDSCH reception in multi-DCI based multiple TRPs | Lenovo, Motorola Mobility |
| 32 | R1-2106872 | Additional enhancements for multi-beam | Samsung |
| 33 | R1-2107210 | Discussion on further enhancements for multi-beam operation | OPPO |
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