**3GPP TSG RAN WG1 #103-e R1-2009715**

**e-Meeting, October 26th – November 13th, 2020**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#4 for multi-beam enhancement

**Document for:** Discussion and Decision

1. Introduction

Picking up from where the group left off in the moderator summaries R1-2009499 and R1-2009574, the 1st GTW session, the 1st and 2nd check-points, below are the summaries and moderator proposals.

1. Summary

We will focus on some of the moderator proposals not included in the agreements from the first and second check-points and the UL parameters.

* 1. Issue 1 (unified TCI framework)

The discussion of UL parameters was not concluded due to lack of inputs. This time, we aim at reaching some conclusion.

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| Action: Interested companies are encouraged to provide their preferences in below and, if any, their reasoning in  Goal: Select one of the three alternatives and, after that, formulate a proposal for endorsement |

Table 1 Additional inputs: for round-4 discussion: UL parameters

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| **Issue** | **Companies’ views** |
| Additional parameters included in or concurrent with (but not included in) unified TCI   * **Alt1**. Include as a part of unified TCI framework (as a part of the UL spatial reference in TCI state definition) * **Alt2**. Outside of but linked to unified TCI framework (linked by RRC configuration) * **Alt3**. Outside of and not lined to unified TCI framework * **Alt4**. Include concurrently with but outside unified TCI framework (independently signaled without pre-configured linkage between TCI and PC parameters) | **UL PC parameters (P0/alpha, CL index)**   * **Alt1 (4)**: LG, Fraunhofer, Interdigital, Intel, Qualcomm (2nd preference) * **Alt2 (10)**: Apple, OPPO, ZTE, MTK (associated by RRC or MAC-CE), Sony, NTT Docomo, CATT, Nokia/NSB, Samsung * **Alt3 (4)**: vivo, Ericsson, Huawei, HiSilicon * **Alt4**: Qualcomm (1st preference)   **PL RS**   * **Alt1 (7)**: OPPO, LG, Ericsson, Fraunhofer (first preference), Interdigital, Intel, Samsung, Qualcomm (2nd preference) * **Alt2 (8)**: ZTE (first priority), MTK, Sony, NTT Docomo, Fraunhofer (linked by RRC or MAC-CE), CATT, Nokia/NSB * **Alt3 (6)**: Apple, ZTE (second priority, reusing periodic QCL-TypeD RS), MTK, vivo, Huawei, HiSilicon * **Alt4: Qualcomm (1st preference)** |

Note that these alternatives can be further elaborated as follows:

* Alt1 incorporates UL parameter setting into TCI state definition. For joint DL/UL TCI, the UL parameter setting is included in each of the joint TCI states. For separate DL/UL TCI, the UL parameter setting is included only in each of the UL-only TCI states – but not necessarily in DL-only TCI states. For unified TCI framework:
  + Alt1 facilitates TCI-state-specific UL parameter setting (e.g. “beam-specific” UL PC)
  + Alt1 implies that the same (common) UL parameter setting applies to the channels and signals where the common TCI applies (thus far, at least dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC)
* Alt2 defines UL parameter setting outside the TCI state definition but allows linkage between the UL parameter setting and each of the TCI states (joint DL/UL or UL-only for separate DL/UL). For unified TCI framework:
  + Alt2 also facilitates TCI-state-specific UL parameter setting (e.g. “beam-specific” UL PC)
  + Alt2 also implies that the same (common) UL parameter setting applies to the channels and signals where the common TCI applies (thus far, at least dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC)
* Alt3 does not associate UL parameter setting with each of the TCI states, i.e. the UL parameter setting is independent of TCI state. Naturally, the UL parameter setting is outside the TCI state definition.
  + Alt3 does not facilitates TCI-state-specific UL parameter setting (e.g. “beam-specific” UL PC)
  + Alt2 also implies that different UL parameter settings can apply to different UL channels/signals

**FL observation**:

* It is important to finalize this issue in this meeting to facilitate better progress on UL TCI design, e.g. pools, UL TCI state update for separate DL/UL.
* There does not seem to be any functional difference between Alt1 and Alt2 although Alt1 results in lower RRC overhead.
* The main advantage of Alt1/Alt2 includes facilitating beam-specific UL parameter setting. However, it is restrictive since different UL channels/signals will have share the same UL parameter setting.
* The main advantage of Alt3 includes facilitating channel/signal-specific UL parameter setting.

Table 2 Additional inputs (if any) for round-4 discussion: UL parameters

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| **Company** | **Input** |
| Apple | Our views are provided in the table.  We think the DL RS for beam indication can be used as PL-RS, this can help to reduce the possibility of mismatch between UL Tx beam and DL Rx beam for PL measurement. |
| OPPO | Our views for each aspect are provided in the table. |
| LG | For additional parameters, UL timing parameter should be considered that each UE panel can be associated to same or different TRP. Especially for the different TRP, large difference of propagation delay to each TRP is quite critical. Not only for mTRP cases, inter-panel delay should also be taken into account that the timing difference between panels can be increased depending on the geometry of the panels and implementation error/calibration for panel. |
| ZTE | Regarding PL RS, considering that semi-persistent or aperiodic RS can be configured as QCL Type D RS in TCI state, Alt2 (explicitly mapping) should be supported as baseline. But, we may live with the solution of reusing QCL Type D RS for PL RS if the QCL Type D RS is periodic as in Rel-16 default UL beam. |
| MediaTek | For PL RS, both Alt2 and Alt3 can be supported, similar to Rel-16. |
| Sony | Our views are given for UL parameters in the table. Simple solution in our view is to allow all UL PC parameters concurrently along with unified TCI state. |
| NTT Docomo | **Alt.1 vs Alt.2**  Since “A pool of joint DL/UL TCI state” is already agreed, the TCI state is used for DL as well. If the TCI state is used for DL, the signaling of UL PC parameters/PL-RS are useless. Hence, we don’t prefer to include UL PC parameters/PL-RS to a TCI state. Instead, we can configure the association between UL PC/PL-RS parameters and the unified TCI configuration.  **Alt.2 vs Alt.3**  Since it is beneficial to align the UL beam and PL-RS (as supported in Rel.16), we believe it is good to update UL PC parameters/PL-RS when the indicated TCI is updated.  In short, we support Alt.2 for both UL PC parameters/PL-RS. |
| vivo | SRI in DCI field can still be used for P0/alpha and CL index related indication.  If the RS used for beam indication is not used for PL RS, then SRI could also be reused for indication of pathloss RS. |
| Ericsson | The power control parameters may be different for different channels, so it would make sense to have it outside the unified TCI framework.  The pathloss RS is tightly coupled with the UE Tx beam, so it would belong with the UL TCI. When SRS is used to determine the UL Tx filter, a separate DL RS need to be provided. |
| Fraunhofer | Inclusion of the PL RS and the UL PC parameters in the TCI state would be our first preference. At least in the case of PL RS, the alignment with the spatial relation RS can be performed with the indication of a single TCI state. |
| Huawei, HiSilicon | In R15/R16, the power control parameters for PUCCH, PUSCH, and SRS are separately configured, for the reason that they are transmitted in different form/format(s) and targeted for different SNR regions. With this in mind, we prefer to keep power control parameters separated from TCI state in R17.  Similar as in R16, in the case where the PL-RS is not configured, the indicated source RS inside the joint DL/UL TCI state, if it is a periodic DL RS, can be used as PL-RS, and hopefully not being restricted to QCL-TypeD RS, which is not applicable to FR1.  In addition, the formulation of Alt-2 is a bit strange. In our understanding, in R16, the linkage between UL beam indication (i.e., SRI) and PL-RS, can be updated via MAC-CE, with which RRC involvement is not always required. So if we go with Alt-2, the design may be worse than R16. |
| CATT | Our views are provided in the table. |
| InterDigital | Our views are provided in the table. Especially, for PL-RS, we prefer to have it as an independent configuration for better flexibility. |
| Intel | Views are updated in the table.  One clarification: when we say unified TCI, does it include both joint DL/UL TCI and the separate UL-only TCI state?  [FL: correct]  We also prefer to include this in the UL-only TCI state for separate beam indication. It would be beneficial to probably finalize the design of UL-only TCI first and then use it as a reference for DL/UL joint TCI |
| Nokia/NSB | Alt 2. As baseline.  During Rel-15/16, it has been well discussed that the pathloss and uplink MAI depends on beam of each UE, but similarities can be found among multiple beams or multiple combination of UEs, in case of MAI. Based on such observation and also based on the practical issue that UE has limited capability on tracking multiple RS for pathloss measurement, Rel-15/16 defined power control parameters to be separately configured, but to be associated to SRI, the uplink spatial filter indicator. No reason we would have to change those approaches.  We consider Alt 1 as optimized solution to reduce RRC overhead, and we think it could work in some limited cases.  We think Alt 3 will bring mostly new design or it would bring severe restriction on flexibility of adaptive power control such as changing of PL-RS according to UL beam, which is already well supported from Rel-15. |
| Samsung | Our views are provided in the table above. |
| FUTUREWEI | For Alt1, the parameters could be included in the TCI states, which lacks flexibility but may be fine for rather static parameters such as P0/alpha. The inclusion may be done via indexes / references to parameters defined elsewhere, or done via direct inclusion of the parameters themselves (not preferred by us).  For Alt2, the wording “Include with” and “but outside” seem contradictory. We suggest removing “Include” here. Also the link by only RRC is restrictive and MAC should be allowed.  For Alt3, it is unclear what “Not include” implies. Does it mean for different TCI states, a common default is used? Please clarify.  Note that PL RS needs not to be the source RS for QCL-TypeD and the PC parameters can be different for different uplink channels and SRSs.  Some further clarifications / discussions are needed. |
| Qualcomm | Added Alt4, which is our 1st preference. The TCI and PC parameters should be updated simultaneously but without any pre-configure linkage between them to provide fastest and most flexible mapping. Otherwise, the fast beam update will be delayed by the PC parameter update, which may become the bottleneck. Also, the number of active beams and PL RSs supported by UE can be different, so they cannot be always 1-to-1 mapped.   * **Alt4**. Include concurrently with but outside unified TCI framework (independently signaled without pre-configured linkage between TCI and PC parameters)   We are also fine for Alt1, which gives less flexibility than Alt4 due to RRC pre-configured mapping between beam and PC parameters. But we think Alt1 may be allowed at least for some TCI states, since spatial relation in R15 for PUCCH is RRC pre-configured with both UL beam indication and PC parameters. |

* 1. Issue 3 (beam indication signaling medium)

“for joint beam indication” text

**Agreement**

On beam indication signaling medium to support joint or separate DL/UL beam indication in Rel.17 unified TCI framework:

* Support L1-based beam indication using at least UE-specific (unicast) DCI to indicate joint or separate DL/UL beam indication from the active TCI states
  + The existing DCI formats 1\_1 and 1\_2 are reused for joint beam indication
    - FFS: If additional DCI format(s) are supported, e.g. existing DCI formats 0\_0, 0\_1, 0\_2, 1\_0 as well as new DCI format(s) dedicated for beam indication

The part of the agreed text was “(for) beam indication” (‘joint’ was in red since it was suggested and discussed but without conclusion, therefore the word ‘joint’ is not yet agreed). During the discussion several versions were proposed:

1. V1. “for joint and separate DL/UL beam indication”: This is equivalent to “for beam indication” since the unified TCI framework comprises joint and separate DL/UL.
2. V2. “for joint DL/UL beam indication”: This keeps the separate DL/UL mode open. The rationale is that DCI 1\_1/1\_2 only includes DL assignment (but not UL grant). In this case, UL-only beam indication (used when, e.g. MPE event occurs) can only be done when DL assignment is available thereby resulting in poor latency performance.
3. V3. (reworded) “for joint DL/UL beam indication, as well as DL-only beam indication in case of separate DL/UL beam indication”: This keeps only the UL part for separate DL/UL mode open. The rationale is the same as V2 and there is no reason not to use DCI 1\_1/1\_2 for DL-only beam indication.

**Observation 1**: Companies’ preferences can be summarized as follows (along with the primary arguments made by some of the proponents). Since V2 is supported by only 1 company who also supports V3, it is removed (see [1] for details).

* V1 (“for joint and separate DL/UL beam indication”):
  + Supported by (14): Apple, OPPO, NTT Docomo, LG, Spreadtrum, Nokia/NSB, Huawei/HiSi, Ericsson, Intel, Fraunhofer IIS/HHI, vivo
  + Main arguments (so far):
    - Against V3 with dedicated DCI (previous UL Tx beam) it’s unclear why NW schedule such transmission given the MPE event. Against V3 with UL DCI, it’s unclear the NW would know if the UE received the DCI or not, given that there is no ACK for UL DCI
* V3 (“for joint DL/UL beam indication, as well as DL-only beam indication in case of separate DL/UL beam indication”):
  + Supported by (16): Qualcomm, CATT, ZTE, NTT Docomo, Xiaomi, MediaTek, APT, Samsung, Futurewei, Fraunhofer IIS/HHI, IDC, Lenovo/MoM, Sony, AT&T
  + Main arguments (so far):
    - For V3 with UL DCI, the time point(s) of separate DL and UL beam indication may be different with high probability. Utilizing UL DCIs for UL scheduling seems reasonable.
    - Against V1, UL-only beam indication (note: perhaps used *only* when MPE event occurs) can only be done when DL assignment is available thereby resulting in poor latency performance and restriction

It is apparent that there is no consensus in changing the text of the agreement (to either V1 or V3). Therefore, the agreed text remains as “The existing DCI formats 1\_1 and 1\_2 are reused for beam indication”. This implies that DCI formats 1\_1 and 1\_2 can be used for both joint DL/UL and separate DL/UL TCI state update (beam indication).

**Observation 2:** In terms of TCI state update (beam indication) signaling and ACK mechanism:

* The use of DCI format 1\_1 and 1\_2 for joint DL/UL and DL-only (in case of separate DL/UL) TCI state update (beam indication) is quite clear.
* However, the use of DCI format 1\_1 and 1\_2 for UL-only (in case of separate DL/UL) TCI state update (beam indication) needs more clarification – at least to address the drawbacks pointed out by the proponents of V3 (note: the ACK mechanism is clear, but how to respond to MPE event in a timely manner without dependence on DL assignment is unclear)

**Observation 3**: Those supporting V3 essentially proposes the support of a new DCI for UL TCI update (UL beam indication), which can potentially be used for DL TCI update (DL beam indication) – either with joint or separate DL/UL beam indication:

* Regardless whether this is a “brand new” format or based on an existing format (such as 1\_0, 0\_0, 0\_1, or 0\_2), this constitutes a dedicated DCI format for beam indication since the following will have to be introduced: 1) TCI field(s), 2) an acknowledgment mechanism.
* Likewise, the points raised by the proponents of V1 against V3 (especially by Huawei) need to be addressed in the dedicated DCI format design

In light of the above observation, the following proposal is made:

**Proposal 3.A**: In RAN1#104-e, on the Rel.17 L1-based TCI state update (beam indication) for the unified TCI framework, interested companies are to provide the following:

* How to use DCI formats 1\_1 and 1\_2 for UL-only (in case of separate DL/UL) TCI state update (beam indication), e.g.
  + Note: The agreement implies that DCI formats 1\_1 and 1\_2 can be used for UL-only TCI state update beam indication). Here, the goal is to progress on the design and provide a better reference for assessing whether additional DCI format(s) dedicated for UL-only are needed
  + Note: Per agreement, this solution includes activating only one TCI state via MAC CE
  + Assess whether the dependence of UL-only TCI state update (beam indication) on DL assignment is acceptable for typical use cases
  + FFS: Additional acknowledgment mechanism directly in response to decoding DCI format 1\_1 and 1\_2 command, e.g., analogous to SPS PDSCH release
* FFS: whether/how to support at least one additional DCI format dedicated for UL-only beam indication (in case of separate DL/UL), including:
  + Whether the format can also be used for DL-only beam indication (in case of separate DL/UL) and joint DL/UL beam indication
  + Whether it is a “brand new” format or based on some extension of the existing DCI formats other than 1\_1 and 1\_2 (e.g. 1\_0, 0\_0, 0\_1, or 0\_2)
  + Acknowledgment mechanism, e.g. analogous to SPS PDSCH release
* Decide if the maximum number of activated TCI states can be kept as 8 (cf. Rel.15/16) or should be increased

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| Action: Interested companies are encouraged to provide their inputs on Proposal 3.A  Goal: Arrive at an agreeable (potential) revision of Proposal 3.A |

Table 3 Additional inputs for round-4 discussion: Joint beam indication proposal 3.A

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| **Company** | **Input** |
| Apple | We think it can be handled by MAC CE design. Similar to multi-TRP design, in MAC CE, gNB can configure the indication for each TCI codepoint in DCI. To support separate UL beam indication, gNB can configure one TCI-codepoint to map with 1 UL TCI.  The MAC CE can configure the indication of each TCI codepoint in DCI to provide flexibility for all kinds of functionalities. |
| OPPO | Using DCI 1\_1 and 1\_2 to indicate UL TCI state can be supported by mapping UL TCI state to TCI codepoint in the DCI format.  However, we prefer to support a dedicated DCI format with small payload size for TCI state indication, which can support both joint and separate TCI state update. |
| LG | Support FL proposal in general. Regarding MPE, we think that MPE-related reporting mechanism from UE should be clarified firstly. |
| ZTE | Although we have already agreed that the ACK/NACK procedure corresponding to PDSCH can be reused when DCI format 1\_1/1\_2 is applied for beam indication, we still think it may not be sufficient and some enhancement may be needed.   * It is due to the fact that, when receiving a NACK response, gNB still fail to understand that it occurs because of DTX or failure of PDSCH decoding. For former, a retransmission of DCI for beam indication is required; but for latter one, the gNB only need to consider how to handle PDSCH retransmission, e.g., lower MCS, using the new indicated beam. * Consequently, even for DCI format 1\_1 and 1\_2, we still need to reconsider the ACK/NACK procedure corresponding to DCI reception directly, e.g., analogous to SPS PDSCH release. This issue may be more serious if reusing this DCI formal for UL only case is supported.   Consequently, we have the following update:  **Proposal 3.A**: In RAN1#104-e, on the Rel.17 L1-based TCI state update (beam indication) for the unified TCI framework, interested companies are to provide the following:   * FFS: Acknowledgment mechanism directly in response to decoding DCI format 1\_1 and 1\_2 command, e.g., analogous to SPS PDSCH release. * How to use/extend DCI formats 1\_1 and 1\_2 for UL-only (in case of separate DL/UL) TCI state update (beam indication), e.g.   + How to respond to MPE event in a timely manner without dependence on DL assignment * (In a best effort manner) decide whether to support at least one additional DCI format dedicated for UL-only beam indication (in case of separate DL/UL), including:   + Whether the format can also be used for DL-only beam indication (in case of separate DL/UL) and joint DL/UL beam indication   + Whether it is a “brand new” format or based on existing DCI formats other than 1\_1 and 1\_2 (e.g. 1\_0, 0\_0, 0\_1, or 0\_2)   + Acknowledgment mechanism   + How to respond to MPE event in a timely manner |
| MediaTek | On using DCI 1\_1 and DCI 1\_2 for UL-only TCI update, we see there is no problem since it can be achieved by MAC-CE associating two TCI states with a codepoint, one for DL and one for UL. No additional DCI field is needed.  On using DCI 0\_1 and DCI 0\_2 for UL-only TCI update, we see it is natural and essential for instantly UL TCI updating when MPE event happens on UE. Regarding observation 3, we don't agree that introducing a new DCI format is essential since we just need to have an additional TCI field in existing DCI 0\_1 or DCI 0\_2. In Rel-16, tons of optional DCI fields are introduced for different purposes, thus it is not a new thing. For the acknowledgement of DCI 0\_1 and DCI 0\_2, the scheduled PUSCH transmission can be used as the acknowledgement. NW can schedule a PUSCH transmission after UL TCI is updated, and NW can confirm the UL TCI update once NW successfully receives the PUSCH. Similar mechanism is already used in BWP switching with UL DCI.  In summary, whether to use DCI 0\_, DCI 0\_2, DCI 1\_1, and DCI 1\_2 for UL-only TCI update can be discussed in the next meeting. We can agree the proposal if it doesn't preclude any above options for UL-only TCI update. |
| Sony | **V3:** as for UL DCI, there is no explicit HARQ-ACK for scheduled PUSCH in Rel.15/16. But anyway gNB could determine whether UL DCI is correctly received by UE by checking the scheduled PUSCH. On the other side, the UE can be provided with implicit ACK/NACK by monitoring UL DCI (same HARQ process ID and toggled NDI field).  **V1:** If one would like to apply DL DCI to conduct UL TCI state, then DL TCI and UL TCI should share all 8 (3bits) TCI state code points assuming no change to Rel.16 1\_1 and 1\_2 DCI formats. Therefore, both DL and UL dynamic beam switch would be impacted.  We are okay to study and specify if needed new DCI format which could be used for dedicated TCI state indication for either joint TCI state or separate TCI (DL or UL). |
| NTT Docomo | Support. Following part look like to consider new DCI format only, which is contradict to the second sub-sub bullet. Hence, we suggest to add following:   * (In a best effort manner) decide whether to support at least one additional DCI format or additional DCI field in existing DCI format(s) dedicated for UL-only beam indication (in case of separate DL/UL), including:   [FL: Thanks, but there is no contradiction since adding a new DCI field in existing format other than 1\_1/1\_2 is still considered an additional DCI format – see Observation 3] |
| vivo | The following statement with “timely” description seems implying the response for MPE event needs to be at the same level of latency as the beam indication itself. In our understanding, MPE event triggering, report and corresponding response is at the level of seconds, rather than at the level of ms.   * ~~How to respond to MPE event in a timely manner~~   Regarding the mechanism to support indication of UL beam for separate DL/UL mode, the sigaling method provided by Apple seems a good way to go. |
| Ericsson | We note that we have agreed that we reuse DCI formats 1\_1 and 1\_2. This means that extend is FFS, and should be treated as such. Suggest to remove.  The subbullet “How to respond to MPE event in a timely manner without dependence on DL assignment” is vague. Suggest to remove.  It was previously agreed that other DCI formats are FFS. It is unclear why there is a new formulation. We propose to stay with the FFS formulation.  Thus:  **Proposal 3.A**: In RAN1#104-e, on the Rel.17 L1-based TCI state update (beam indication) for the unified TCI framework, interested companies are to provide the following:   * How to use DCI formats 1\_1 and 1\_2 for UL-only (in case of separate DL/UL) TCI state update (beam indication), e.g. * FFS whether to support at least one additional DCI format dedicated for UL-only beam indication (in case of separate DL/UL), including:   + Whether the format can also be used for DL-only beam indication (in case of separate DL/UL) and joint DL/UL beam indication   + Whether it is a “brand new” format or based on existing DCI formats other than 1\_1 and 1\_2 (e.g. 1\_0, 0\_0, 0\_1, or 0\_2)   + Acknowledgment mechanism   + How to respond to MPE event in a timely manner   [FL: Removing MPE is fine but we need to assess if there is some serious issue pointed out by companies. Added a note that this doesn’t imply the support is open] |
| Fraunhofer | Support the proposal in principle. |
| Huawei, HiSilicon | Regarding the 1st sub-bullet, as commented by Apple/MTK/vivo, we don’t see a need to ‘extend’ DCI formats 1\_1 and 1\_2, and we suggest removing the phrase of ‘extend’.  Regarding the 2nd sub-sub-bullet, once MPE event happens and is reported to NW, NW can simply send in a MAC-CE to update the mapping of TCI codepoints (so that the UE panel/beam experiencing MPE event is no longer used). In this case, there is no dependence on DL assignment, and we suggest removing this sub-sub-bullet.  Regarding the 2nd sub-bullet, instead of saying ‘(In a best effort manner) decide whether’, we suggest changing back to previous/conventional formulation – put it as ‘FFS: Whether/how to’. |
| CATT | We prefer to support a dedicated DCI format for both joint DL/UL beam indication and separate DL/UL beam indication, considering beam indication may not be related to data scheduling. |
| Intel | Current DL DCI formats can be used to support UL-only beam indication possibly by MAC-CE update i.e., mapping a UL-only TCI state to a codepoint in DCI (We can further discuss if we need to increase the number of active codepoint to more than 8 for large number of TCI states). Implications of common or separate TCI state pool may also need to be considered.  [FL: This is an issue we need to discuss]  Additionally, we can also extend current UL DCI formats to support a TCI state indication field for cases when gNB may want to update UL beam without the need for a DL grant.  If no UL DCI format is supported, that would necessitate a “brand new” DCI format and it is unclear at this time if that is needed. We suggest removing the “(In a best effort manner)” from the second bullet since a decision one way or other would help clarify beam indication design. |
| Nokia/NSB | Support FL’s proposal |
| Samsung | In general, we supportive of this proposal.  How to extend DCI formats 1\_1 and 1\_2 to indicate UL TCI state in case of separate DL/UL TCI states, we are open to consider adding a new field to the DCI Format to indicate the UL TCI state (in case of separate indication), or using the existing field to indicate UL TCI state.  Regarding the need for a new format for TCI state indication we are open to consider:   1. Using an UL-related DCI for TCI state indication. This is beneficial in case of uplink heavy traffic, the NW can use the UL-related DCI to indicate a new beam at least for UL-only beam indication (in case of separate DL/UL beam indication) and Joint DL/UL beam indication. DL-only beam indication in an UL-related DCI can be further studied. 2. Using a DCI specifically for TCI state indication. The benefit being is that we decouple the TCI state indication for the scheduling of DL and UL data. This can be useful especially for semi-persistent DL transmissions and uplink configured grant. 3. The ACK mechanism from Rel.15 SPS PDSCH release can be reused   For acknowledgment mechanism, for DL and UL related DCIs, the UE usually responds with an uplink transmission (either HARQ-ACK or PUSCH), we can use that transmission as an acknowledgement of reception of the corresponding DCI. Using this acknowledgment mechanism simplifies the design (avoids the need for designing a separate feedback channel). However, if it can be shown that by having a separate feedback mechanism for DL or UL related DCI performance improves, we are open to consider further. |
| AT&T | Support the FL proposal |
| FUTUREWEI | Our preference is to support a new DCI format which is dedicated for beam indication and can support both joint and separate DL/UL beam indication. |
| Qualcomm | Support FL’s proposal. Support dedicated DCI format for fast beam indication without dependence on the traffic. |

UE capability for latency

**(Initial) Proposal 3.B**: On Rel.17 DCI-based beam indication:

* Regarding application time of the beam indication: if beam indication is received, down-select from the following:
  + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication
  + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication
  + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y
* FFS: When and how to apply the minimum beam indication delay
* Support a UE capability for the minimum value of X or Y
  + FFS: the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability
  + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE
  + FFS: Whether to support more than one values of X/Y and UE capabilities for the minimum values of X/Y
  + FFS: whether existing UE capability (e.g. beamSwitchTime) can be reused as this UE capability.
* The latency of the DCI design (with or without specification impact) should be significantly improved with respect to the utilization of MAC CE

Only the blue highlighted text was still in flux during the discussion.

Based on the inputs below, Proposal 3.B is modified below as a starting point for GTW discussion (especially the bracketed texts):

**Revised Proposal 3.B**: On Rel.17 DCI-based beam indication:

* Regarding application time of the beam indication: if beam indication is received, down-select from the following:
  + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication
  + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication
* [FFS:] Support a UE capability for the minimum value of X or Y
  + The beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability
  + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE
* FFS: whether existing UE capability (e.g. beamSwitchTime, TimeDurationforQCL) can be reused as this UE capability
* [Criterion for selecting application time of the beam indication:]
  + AltA wording [The latency of the DCI design (with or without specification impact) should be significantly improved with respect to the utilization of MAC CE]
  + AltB wording [RAN1 strives to reduce the latency of DCI design with respect to the utilization of MAC CE]
  + AltC wording [It is expected that the latency of a DCI-based TCI state update is significantly improved with respect to the latency of a MAC CE-based TCI state update]

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| Action: Interested companies are encouraged to provide their inputs on the revised Proposal 3.B.  Goal: Arrive at an agreeable formulation of the revised Proposal 3.B |

**Observation**: The following contentious issues need to be resolved:

* Third bullet (“Support a UE capability for the minimum value of X or Y”):
  + Support (remove FFS): Apple, Ericsson, MediaTek, NTT Docomo, OPPO, Samsung, Sony
  + FFS: Futurewei, LG, Nokia/NSB, Spreadtrum
* Fifth bullet (criterion):
  + Support: Nokia/NSB
  + Remove: Ericsson, Intel, Huawei/HiSi

Table 4 Additional inputs for round-4 discussion: UE capability of proposal 3.B

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| **Company** | **Input** |
| **After revision** | |
| Apple | We do not quite understand why some companies have concern for the UE capability. There are 3 options to define the action delay:   * Option 1: a predefined value * Option 2: a UE capability * Option 3: unspecified – up to UE implementation   Option 1 often leads to the worst case and prohibits UE to have an opportunity to do a better job. We are also ok for option 3. But option 2 is our typical way. |
| OPPO | We do not support to put UE capability with FFS. Naturally, the minimum time shall be a UE capability. If no UE capability is defined and we specify a predefined value in the spec, then we will have to choose a very large value to accommodate the worst scenario, which would be even worse for this feature. |
| LG | We suggest to add the following FFS back.   * + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y   As commented in email, DCI to PDSCH timing and PDSCH to HARQ-ACK timing is already well defined in Rel-15/16, so we cannot agree on the first bullet without having the FFS above.  [FL: Although the FL thinks this is fine, at least 3 companies raised some concern on this and at least 2 companies suggested that this is essentially the same as the 4th bullet] |
| ZTE | In our views, we support gNB configuration/indication for action delay due to the fact that this delay is not only related to UE capability but also relevant to handle DCI retransmission from gNB perspective. It seems that we may have two candidates for gNB configuration, e.g., by RRC or by DCI (e.g., reuse the existing field for PDSCH reception). At the first stage, we prefer to keep this door open, and let’s make decision at the next meeting.  BTW, timeDurationForQCL is UE capability parameter and should be typed together. Please check my minor update:   * [FFS:] Support a UE capability for the minimum value of X or Y   + [FFS:] the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling or DCI command based the UE capability   + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE * FFS: whether existing UE capability (e.g. beamSwitchTime, timeDurationForQCL ~~TimeDuration for QCL~~) can be reused as this UE capability   [FL: Although the FL is fine with this, at least 2 companies raised some concern on adding “DCI command”] |
| MediaTek | We see either Alt1 or Alt2 will requires UE capability. If there is UE capability, application time has to be controlled by NW. Thus, we prefer to remove the FFSs for the following two bullets:   * ~~[FFS:]~~ Support a UE capability for the minimum value of X or Y   + ~~[FFS:]~~ the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability   Again, we don’t support the “or DCI command” added by ZTE due to no clear motivation, even in FFS. |
| Sony2 | We support the UE capability on beam indication delay. Either defining new UE capabilities or reusing existing ones, i.e. BeamSwitchTiming or QCLTimeDuration can be decided later. |
| NTT Docomo2 | Support FL proposal. We agree with Apple. Either “a predefined value” or “a UE capability” would be needed for the action delay.  If we agree on Alt2 of the proposal 3B, we believe 0ms action delay is possible. |
| Vivo2 | We are supportive of reusing current UE capability for TimeDuration for QCL. |
| Ericsson | The use of FFS in brackets is a little confusing. We propose the following modifications:   * Support a UE capability for the minimum value of X or Y   + the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability   The remaining FFSs are OK, but some would seem superfluous:   * FFS: When and how to apply the minimum beam indication delay   “when” is described in the first bullet with Alt1 and Alt2. “How” is quite unclear.   * FFS: whether existing UE capability (e.g. beamSwitchTime, TimeDuration for QCL) can be reused as this UE capability   This would seem extremely unlikely, and the benefits are unclear.  For the final bullet:   * Criterion for selecting application time of the beam indication:   We are not sure why this is needed. If we have a UE capability, the value advertised by the UE will determine the application time, in combination with the NW configuration. If the intention of the statement is to rule out the UE capability or the NW configuration, we do not support any such statement. |
| Fraunhofer | The support of the UE capability can be confirmed and not be added as FFS (i.e., remove the FFS in front of ‘Support a UE capability…’). |
| Huawei, HiSilicon | Regarding Alt-1 under the 1st bullet, if our understanding is correct, we suggest adding a note: This alternative implies the ACK is transmitted with the indicated beam and DCI carrying beam indication is hence not protected by ACK.  [FL: The FL doesn’t share the same understanding. Alt1 still requires ACK transmission. It enables the NW to assume the UE receives the DCI before receiving the ACK. If the NW needs to signal a new beam indication before receiving the ACK, the NW will anyway do so. If the NW later doesn’t receive an ACK after the expected ACK latency is reached, the NW will send a new beam indication regardless whether a new beam indication is deemed necessary (if the optimum beam changes) or not (if the optimum beam stays the same)].  Regarding the last bullet, it is unclear to us whether DCI will be used for indicate switching cell during L1/L2 inter-cell mobility or switching to a UE panel which was in inactive status. With these in mind, we don’t think it is a good idea to agree on such vague statement and suggest removing them. |
| Intel | For the last bullet, (1st and 3rd sub-bullets) it is still unclear to us what “significant improvement” means. We would like to clarify what will be the actual criterion of determining this “improvement”. Will this be based on SLS results with the agreed evaluation assumptions?  For the second sub-bullet, since we already agreed to support TCI based beam indication, we do not see the value of this statement in the agreement. The overall delay depends on Alt1 or Alt2 compared to MAC-CE update. |
| Nokia/NSB | We need to repeat ourselves; we are not OK to agree on a UE capability before we see that this implies, values, improved latency, etc. Hence the proposal:   * FFS: Support a UE capability for the minimum value of X or Y   + ~~[FFS:]~~ the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability   + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE |
| Samsung2 | Support the update proposal, with the following comments:   * First FFS can be removed (when and how to apply the minimum beam indication delay), this seems to be redundant with the first bullet (including Alt1 and Alt2) |
| AT&T | We support this proposal in principle. We agree with Ericsson and Nokia that the FFS on the gNB configuration can be removed. It would also be good to quantify what “significant improvement” means for the criterion for selection. |
| FUTUREWEI | As in our previous comments, it is better to discuss UE capability later after designs are clearer. At this point, we suggest to first discuss the timeline of TCI update (beam indication) via DCI which should target for much short latency than that of MAC CE. |
| Qualcomm | We prefer to make the UE capability as FFS. A single fixed value may be beneficial to simplify the signaling. Because the values supported by different UEs may not be significantly different. The spec already has fixed value of 28 symbols for beam reset latency in case of BFR, which is common for all UEs. In addition, MAC-CE based activation also has a common fixed value of 3ms.   * FFS: Whether to Support a UE capability or a common fixed value for the minimum value of X or Y. If UE capability is supported,   + FFS: the beam application time X or Y is configured by the gNB via higher-layer (RRC) signaling based the UE capability   + FFS: the exact minimum values of X (e.g., 0.5ms, 2ms, 3ms) or Y supported by UE |

* 1. Issue 6 (beam refinement/tracking)

**(Initial) Proposal 6.A**: Investigate and, if needed, specify the following enhancements for beam refinement/tracking in Rel.17:

* Group 1: Beam measurement and reporting enhancement, including Msg3/RO-based/MAC-CE-based beam reporting
* Group 2: Improving efficiency (latency and/or overhead) of beam refinement assuming the unified TCI framework (issue 1):
  + Enabling joint DL TX and RX beam refinement/tracking (P2+P3)
  + Additional UE report to aid P1/P2/P3 related measurement/report configuration (triggering frequency or periodicity)
* Group 3: Beam management with reduced latency and DL signaling assuming the unified TCI framework (issue 1):
  + Dynamic beam update based on beam report (with or without beam indication)
  + Dynamic beam measurement and report triggered by beam indication (without CSI-RS/CSI triggering)
  + Configuring/indicating to UE multiple SSBs for beam tracking
  + Semi-static/pre-planned (RRC based) beam transition (for, e.g. isolated HST deployment)
  + Reducing activation delay of TCI states (e.g. via storing QCL properties of a subset of source RSs for a time period, triggering temporary/aperiodic RS considering UE supported number of active TCI states)
* The scope of investigation (including down selection or combining) will be within and/or across the three groups. Consider the dependence on issue 1 and 3 (including their maturity) for the specification work on issue 6, if any

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| Action: Interested companies are encouraged to provide their inputs on Proposal 6.A  Goal: Arrive at an agreeable formulation of Proposal 6.A |

**Observation**: Despite the majority support of the above proposal, some companies still raise the following concerns:

* De-prioritization relative to issues 1 to 5 (postpone starting time): ZTE, vivo, Huawei/HiSi, Nokia/NSB
  + Note: The last bullet already inevitably postpones any significant study/work before issues 1 and 3 progress toward maturity
* Down scoping (reducing the number of items):
  + Remove group 1: LG (move to CE WI), Intel (move to CE WI), Huawei/HiSi
    - Note: There will be some RAN level discussion on where to handle group 1 (FeMIMO vs. CE). But this is a RAN-level matter
  + Choose only a subset of sub-items: OPPO, Nokia/NSB
    - Note: This can be a good starting point when the investigation work starts

Table 5 Additional inputs for round-4 discussion: proposal 6.A

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| **Company** | **Input** |
| Intel | We do not agree that this proposal should be lower priority compared to other proposals in this WI. Based on agreed simulation assumptions, we have provided evaluations in [R1-2008977](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_103-e/Docs/R1-2008977.zip) which show that gains from proposals covered in this section are much larger than many of the other features being discussed. Therefore, we don’t see why the proposals in this section cannot be discussed concurrently with other issues. Additionally, we do not think Group 1 needs to be discussed in MIMO since some aspects can be covered in Coverage Enhancement. Proposals in Group 2 and Group 3 should be discussed further. |
| Huawei/HiSi | Without removing Group 1 and establishing certain prioritization, we still prefer not to agree on Proposal 6.A in this meeting |
| AT&T | we do not agree to the prioritization at this meeting, or to remove group 1 from the discussion at this point. We believe that the FL proposal is a reasonable compromise to investigate and if needed specify enhancements for beam refinement and tracking in Rel. 17, taking into account the maturity of issues 1 and 3 |
| LG | On the last bullet, add: In addition, consider overlapping of scope with other WI/SI, e.g. coverage enhancement (CE). |
| Samsung | Regarding proposal 6.A, we support this proposal. To improve the efficiency (lower latency and lower overhead) of beam management we need to look at both beam refinement/tracking as well as beam indication. Beam indication is well covered by items 1 and 3. Item 6 covers improvements to beam refinement/tracking, which is the second leg to facilitate more efficient UL/DL beam management. We support all 3 groups of proposal 6.A, we think that they should all be investigated.    As a compromise, we can accept Jaehoon’s proposal to make the list of groups 2 and 3 as examples. However, we think that this investigation should be part of FeMIMO and not part of any other WI/SI given its strong relevance to MIMO |
| Apple | We think beam measurement and report should be a good aspect, but we think it is better not to restrict it for RACH. We think our focus should be more for connected mode UE (remove RACH, add AMC CE based reporting) |
| OPPO | Overall, the scope in this proposal is too wide. Down-scoping is needed for reasonable workload. Please note we need to work other 5 big issues in this agenda that are supposed to be with higher priority than Issue 6. From our perspective, the following three items in this proposal have high priority for study, which could benefit the beam tracking:   * + Enabling joint DL TX and RX beam refinement/tracking (P2+P3)   + Additional UE report to aid P1/P2/P3 related measurement/report configuration (triggering frequency or periodicity)   + Dynamic beam measurement and report triggered by beam indication (without CSI-RS/CSI triggering) |
| LG | As suggested via email, we think that it is needed to add the following text:  **In addition, consider overlapping of scope with other WI/SI, e.g. coverage enhancement (CE).**  [FL: At one company has some concern on this. Nevertheless this is a good point that should be raised and handled in RAN-level in December, not in RAN1] |
| ZTE | We still think that issue-6 should be postponed after previous five issues are stable considering the limited GTW and non-F2F meeting. So we suggest to copy the original bullet back.  (Revised) Proposal 6.A: Investigate and, if needed, specify at least the following enhancements for beam refinement/tracking in Rel.17 (with lower priority than the other five issues and later starting point during the WI phase): |
| NTT Docomo | Support. We agree to investigate all 3 groups of proposal 6.A. |
| vivo | Agree with ZTE and still prefer last version with clear definition of above issues with lower priority.  Regarding the following bullet (as a lower priority issue for the purpose of later discussion), we would like to add the following examples:  Reducing activation delay of TCI states (e.g. via storing QCL properties of a subset of source RSs for a time period, or via triggering temporary/aperiodic RS considering UE supported number of active TCI states) |
| Ericsson | Support to investigate these issues with priority: many of the issues are very important. |
| Huawei, HiSilicon | We still have concerns to agree on this mixed proposal, the scope of which is quite broad which may dilute the efforts on Issue 1 ~ 5, and some of them may not even be suitable for discussion in MIMO or RAN1 (e.g., RO, MSG3, activation delay). In our view, companies can study by themselves and the group can check the status later if time permits, with which there is no need to agree on this mixed proposal. If there is decent support on any single proposal, it can be discussed on a case-by-case manner, similar as TEI handling. |
| InterDigital | We propose to update as follows:   * Group 3: Beam management with reduced DL signaling assuming the unified TCI framework (issue 1), for example:   + Dynamic beam update based on beam report (with or without beam indication) |
| Intel | The proposal is to investigate and if needed specify. Our understanding is that companies will bring results to justify the proposals. We think the current scope is good. However, we need to agree to concrete directions for investigation and therefore we suggest removing “for example” from Group 2 and 3 main bullets. |
| Nokia/NSB | We prefer to postpone the decision on proposal 6.A. This is low priority issue as captured in our perspective, and we didn’t have enough change to discuss the validity of this topic yet. We also agree to OPPO’s view that the scope is rather wide and needs further description. |
| Samsung2 | We support this proposal. For group 1, beam reporting for RACH can be by MAC CE or L1 control, we just to reword group 1 as follows:   * Group 1: Beam measurement and reporting enhancement ~~via RACH~~ for example:   + RACH Msg3 beam reporting   + RO-based beam reporting   + ~~(e.g.~~ MAC CE based beam reporting, ~~RO for measurement and MSG3 for reporting)~~ |
| AT&T | We support this proposal and think these issues are important to discuss to enhance the efficiency of beam management. We all agreed that these issues are lower priority compared to more high priority items like issue 1 for example, and they are rightly positioned as such in the FL summary. There is no need for prioritization at this meeting, and especially, there is no need to discard enhancement groups. The proposal is to investigate and if needed to specify, and we believe it is a very reasonable proposal. No need to add “for example” for group 2 and 3. |
| FUTUREWEI | Our view is that it is ok to start specification work on Issue 6 later but we should continue study and no need to intentionally postpone. Some of the enhancements such as “Dynamic beam update based on beam report (without beam indication)” can be considered after Issue 1 and 3. Note that the beam training and tracking latency is a critical issue. We think some efforts are needed there in addition to DCI-based TCI update and beam indication. Otherwise, the end performance may still not be up to what we needed.  The schemes listed under Group 3 are not only with reduced DL signaling, but also with reduced latency. Therefore we would like to add “with reduced latency” to Group 3, e.g., “Beam management with reduced latency and reduced DL signaling ……”. |
| Qualcomm | We prefer to discuss issue 6 in parallel with other issues, at least those without dependency on other issues, e.g. issue 1 and 3. |

# References

1. R1-2009574 Moderator summary#3 for multi-beam enhancement Moderator (Samsung)
2. R1-2009499 Moderator summary#2 for multi-beam enhancement Moderator (Samsung)
3. R1-2008147 Moderator summary#1 for multi-beam enhancement Moderator (Samsung)