**3GPP TSG RAN WG1 #105-e R1-2106086**

**e-Meeting, May 10th – 27th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary for multi-beam enhancement: ROUND 1

**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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| * Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:   + Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility 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)   + 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)

UL PC parameters other than PL-RS

**Proposal 1.1A**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, for PUSCH and PUCCH, the setting is either included in UL TCI state or (if applicable) joint TCI state or associated with UL TCI state or (if applicable) joint TCI state.

* Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling), and whether it is up to RAN2

Note: It has been agreed that the setting of (P0, alpha, closed loop index) is associated with UL channel or UL RS (therefore the setting is channel- and signal-specific)

**vs.**

**Proposal 1.1B:** On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework,

* For each of PUSCH, PUCCH, and SRS, the setting of (P0, alpha, closed loop index) can be associated with UL or (if applicable) joint TCI state.
  + In this case, multiple settings are configured where each setting is associated with at least one TCI state
  + FFS: Details of the association (including the manner it is performed and the signaling), and whether it is up to RAN2
* If not associated, for each of the PUSCH, PUCCH, and SRS, only one setting of (P0, alpha, closed loop index) per channel/signal is configured for all the UL or (if applicable) joint TCI states

Note: It has been agreed that the setting of (P0, alpha, closed loop index) is associated with UL channel or UL RS (therefore the setting is channel- and signal-specific).

Table 1 Additional inputs: issue 1 – UL PC other than PL-RS

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| **Company** | **Input** |
| Mod V0 | **Two alternatives for compromise proposals: 1.1A vs 1.1B**   1. **Proposal 1.1A: to accommodate AltC proponents, AltA/B is made applicable only for PUSCH and PUCCH. This means that AltC is used for SRS** 2. **Proposal 1.1B: proposed by Ericsson as a compromise/synthesis between AltB and AltC (based on Samsung, Apple, and Spreadtrum wording proposals)**   **Please share your inputs on the above proposals** |
| Apple | Support Proposal 1.1B. |
| OPPO | We support 1.1A. the reason is in our view, for SRS resource, the PC parameters (P0, alpha, closed loop index) shall be configured per SRS resource set, but not associated/contained in each TCI states. |
| vivo | The proposals would make the TCI framework design complicated. If the TCI pool is across all CCs, then the the framework would be rather heavy. And we would need three lists.  The legacy framework is working well without further enhancement on this.  [Mod: The option to use of legacy scheme has been removed last meeting. If there is no consensus in this meeting AltC is the default for PUSCH, PUCCH, and SRS – meaning UL PC setting is channel/signal-specific and not TCI-state (beam)-specific] |
| Docomo | Considering the unified solution for PUCCH/PUSCH/SRS in proposal 1.1B, we prefer proposal 1.1B. |
| MediaTek | Slightly prefer P1.1B since it is more flexible for NW configuration. But we would like to clarify the followings:   * Regarding the first bullet, further study the detail of association, and whether it is up to RAN2.      * + FFS: Detains of the association (including the manner it is performed and the signaling), and whether it is up to RAN2   [Mod: Done]   * Regarding the second bullet, whether Rel-15/16 mechanism can be used to provide UL PC parameters for each channel/signal w/o any issue?   + FFS: Whether Rel-15/16 mechanism can be used to provide UL PC parameters for each channel/signal   [Mod: This option has been removed in the last meeting ☹ Please see my comment for vivo] |
| LG | Support Proposal 1.1A.  Regarding Proposal 1.1B, it seems to be clarified on the meaning of ‘only one PC setting’ is configured for all the UL/joint TCI states’. In our understanding, there can be multiple settings configured and a specific one of them would be ‘applied’ (e.g. one default PC setting) if PC setting is not associated for each of PUSCH, PUCCH, and SRS since it could be associated to some (not all) of UL channels  [Mod: It is one setting per channel/signal, not one setting for all channels/signal. Clarified a bit more] |
| Mod V7 | **Revised proposal 1.1B** per inputs |
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PL-RS

**Proposal 1.2**: On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is either included in UL TCI state or (if applicable) joint TCI state or associated with UL TCI state or (if applicable) joint TCI state.

* If the DL source RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS, the choice of RS for path-loss measurement (either the DL source RS in the TCI state or the PL-RS) is up to the UE as assumed in Rel-15/16
* Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling), and whether it is up to RAN2
* The UE maintains the PL-RS of the activated UL TCI state or (if applicable) joint TCI state
* The maximum number of activated UL TCI states or (if applicable) joint TCI states per band per cell is a UE capability
* FFS: detailed aspects of PL-RS, e.g. CSI-RS type(s), time-domain behavior(s), restriction on configuration

Table 2 Additional inputs: issue 1 – PL-RS

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| **Company** | **Input** |
| Mod V0 | **The wording of proposal 1.2 has been relatively stable**  **Please share your inputs, if any** |
| Apple | We can accept this compromise proposal |
| OPPO | Overall the proposal is fine to us.  One clarification question on 4th bullet: here the maximum number activated UL TCI states or joint TCI states intents to specify the UE capability of the maximum number of PL RS the UE can maintain at the same time, right? If so, we suggest to add “per serving cell” there too.   * The maximum number of activated UL TCI states or (if applicable) joint TCI states per band, per serving cell is a UE capability   [Mod: Done (per “cell”)] |
| vivo | The very essential case of DL RS for beam directly used as the PL RS should be firstly agreed. |
| Docomo | We are fine with the proposal. |
| MediaTek | Okay to this proposal |
| LG | For the first sub-bullet, we suggest the following modification below. I understand it is to address the concern on an additional RAN4 test and it is left to UE implementation as in Rel-15/16. If the sub-bullet is maintained with the correct understanding as in Rel-15/16, this modification may avoid the ambiguity related to the UE implementation where a number of companies raise a concern.   * If the DL source RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS, the choice of RS for path-loss measurement (either the DL source RS in the TCI state or the PL-RS) is up to the UE as assumed in Rel-15/16.   [Mod: Yes, done] |
| Mod V7 | **Minor revision** |
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QCL for CA

**Proposal 1.3A**: On Rel.17 unified TCI framework, [a single RRC pool of TCI states is used] for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs

* A CC~~-~~specific source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.
  + The CC-specific source RS is applied to all BWPs within the CC but measured only within the active BWP
  + [FFS: how to provide the CC/BWP-specific RSs in a TCI state of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state]
* “A set of configured CCs/BWPs” includes all the BWPs in the set of configured CCs in one band

**Proposal 1.3X:** ‘A single RRC pool of TCI states’ implies that the single RRC TCI state pool can be configured in a CC and can be shared among the set of configured CCs.

* For QCL Type-A/D, the BWP /CC ID for QCL -Type A/D source RS can be absent in a TCI state
* When the BWP /CC ID for QCL -Type A/D source RS is absent in the TCI state, the BWP /CC ID for QCL -Type A/D source RS is determined according to a target CC of the TCI state and the corresponding active BWP
* For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + QCL TypeA/D RS source ID to locate the corresponding QCL Type-A/D source RS
* Note that cross-CC UL power control indication is FFS as a separate issue
* FFS: inter-band CA, e.g. two or more sets of configured CCs in a UE

Table 3 Additional inputs: issue 1 – QCL for CA

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| **Company** | **Input** |
| Mod V0 | **Given the views of companies in round 0 (super-majority wanting 1.3A and many having concern with 1.3B) and differences among 1.3B proponents regarding the additional QCL rule (e.g. same vs same/different), we will focus on proposal 1.3A and see how this can be reworded to be agreeable.**  **Note: If the proponents of 1.3B can converge, we can introduce 1.3B again for consideration.**  **Proposed for common pool for CA was provided by ZTE (1.3X).**  **Please provide your inputs, if any, for 1.3A and 1.3X** |
| Apple | We support both proposals and we support single RRC pool of TCI states in principle, which is important to reduce UE memory size. |
| OPPO | 1.3A: we do not support. This proposal reverts our previous agreement made in RAN1#103e meeting:     * The agreement made in 103e meeting requires “**same/single RS for QCL TypeD**”, but the proposal 1.3A proposes CC-specific RS for TypeD * The motivation of rel17 TCI for CA is to provide same beam/QCL-TypeD to multiple CCs. The proposal 1.3A does not satisfy that. The CC-specific QCL-TypeD RS associated with same QCL-TypeD RS does not provide same QCL-TypeD/beam for the PDCCH/PDSCH in different CCs.   Proposal 1.3X: we prefer to use CC-specific RRC TCI state pool. The only benefit of using a single RRC TCI state pool is the overhead of RRC can be reduced. But on the other hand, it would impose big restriction on the system scheduling. Furthermore, how much RRC overhead can be saved is unclear, which depends on the ratio of RRC overhead for TCI state pool configuration in the whole RRC configuration. If the RRC overhead for TCI state pool configuration is only a very small portion of the whole RRC configuration, then the benefit of overhead reduction is not so important. |
| vivo | Fine with current version. And also support single RRC pool. |
| Docomo | Support proposal 1.3A.  For proposal 1.3X, as we commented in round 0, both QCL-Type A/D RS are CC specific in proposal 1.3A. But, proposal 1.3X does not clarify behavior of QCL-type D RS. So, we suggest to update as following.  **Proposal 1.3X:** ‘A single RRC pool of TCI states’ implies that the single RRC TCI state pool can be configured in a CC and can be shared among the set of configured CCs.   * For QCL Type-A/D, the BWP /CC ID for QCL -Type A/D source RS can be absent in a TCI state * When the BWP /CC ID for QCL -Type A/D source RS is absent in the TCI state, the BWP /CC ID for QCL -Type A/D source RS is determined according to a target CC of the TCI state and the corresponding active BWP * For each applied active BWP per CC, UE uses the corresponding BWP ID + CC ID + QCL TypeA/D RS source ID to locate the corresponding QCL Type-A/D source RS * Note that cross-CC UL power control indication is FFS as a separate issue * FFS: inter-band CA, e.g. two or more sets of configured CCs in a UE   --  Re OPPO’s comment: Proposal 1.3A says “*The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS*.  Thus, it does not contradict with the previous agreement. |
| LG | We support 1.3A but still preferred with separated RRC pool per CC. |
| Mod V7 | **Minor revision to 1.3X, no revision for 1.3A** |
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’Other’ signals/channels

**Proposal 1.4**: On Rel.17 unified TCI framework,

* Any DL RS or DL physical channel that is a valid target signal/channel of a Rel-15/16 TCI state based on the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool)
  + Note: This does not imply that all such DL RSs and DL physical channels necessarily share a same TCI
* FFS: Whether some SRS resources or resource sets for BM can be configured as a target signal/channel of a Rel-17 UL TCI (hence the Rel-17 UL 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 still TBD)

**Proposal 1.5**: On Rel.17 unified TCI framework, discuss and decide by RAN1#106-e (August 2021)

* Whether each of the following DL RSs and channels can share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC
  + CSI-RS resources for CSI
  + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)
  + CSI-RS for tracking
  + Non-UE-dedicated reception on PDSCH and all/subset of CORESETs
* Whether some SRS resources or resource sets for BM can share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC

**Proposal 1.6**: On Rel.17 unified TCI framework, for any DL RS or DL physical channel that does not share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC, but can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool), discuss and down-select by RAN1#106-e (August 2021) between the following two alternatives:

* Alt1. Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state
* Alt2. Rel-17 TCI state update signaling/configuration mechanism(s) are used, e.g. with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI

Note: For some channels/signals, only one of the above two alternatives may apply (to be discussed).

Note: This does not imply that DL and UL TCI state pools are separate or shared for separate DL/UL TCI (this issue is still TBD)

[FFS: Whether/how the selected alternative can be used to align the Rel-17 DL TCI state between two target channels/signals which do not share the same Rel-17 DL TCI state

* E.g. TCI state #1 can be activated for PDCCH+PDSCH as in Rel-17 and can also be simultaneously configured for a CSI-RS resource for BM as in Rel-15/16.]

Table 4 Additional inputs: issue 1 –‘Other’ signals/channels

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| **Company** | **Input** |
| Mod V0 | **The wording of proposal 1.4-1.6 has been quite stable from last round. The last discussion was only on the last FFS in 1.6.**  **Please share your inputs, if any, on proposals 1.4-1.6** |
| Apple | Proposal 1.4: Support  Proposal 1.5: Support  Proposal 1.6: Support Alt1. |
| OPPO | For proposal 1.6: we support Alt1.  One question on Alt2 in Proposal 1.6: What does it mean by “e.g. with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI”? Is the ‘common’ TCI state indicated by DCI format 1\_1/1\_2 applied here?  [Mod: No. It is to use Rel-17 beam indication for updating another Rel-17 DL TCI independent of the Rel-17 “common” TCI] |
| vivo | Fine with current formulations |
| Docomo | Fine with the proposals. |
| MediaTek | Regarding the last FFS in P1.6, we still think not necessary. Looking into the example under the FFS, why it cannot be done by NW configuration if the same TCI pool is shared across all DL channels/signals? We believe QC’s concern is already addressed by P1.4:   * *Any DL RS or DL physical channel that is a valid target signal/channel of a Rel-15/16 TCI state based on the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool)*   If clarification is really needed, we prefer to conclude it as follows in this proposal w/o FFS.  [Mod: After your explanation, I tend to agree with your conclusion. Alignment seems to be a NW implementation usage of the outcome of down selection in proposal 1.6. FFS is now in brackets to await Qualcomm’s response]  Note: A same Rel-17 DL TCI state or different Rel-17 DL TCI states can be configured/indicated for any two target channels/signals |
| LG | On Proposal 1.4: Support. For clarification, is this correct understanding that the granularity of target channel configuration (e.g. per resource set) will be discussed later after agreeing on this?  [Mod: This is a next-level discussion – relevant after proposal 1.4 and 1.5 are agreed]  Proposal 1.5 and 1.6: Support |
| Mod V7 | **No revision** except putting the last FFS in 1.6 in brackets.  **Qualcomm: please check MTK’s comment**. After this explanation I agree that the FFS is an implementation issue (NW usage of the outcome of proposal 1.6 in a spec transparent manner) |
|  |  |

### Issue 2 (L1/L2-centric inter-cell mobility)

Beam indication

**Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:

* At least for UE reception (on PDSCH and PDCCH) and transmission (on PUSCH and PUCCH) associated with UE-dedicated CORESETs, Rel-17 MAC-CE-based and DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation) for joint TCI [and/or separate DL/UL TCI]
  + {FFS (to be decided in RAN1#106-e): Beam indication support for separate DL/UL TCI in case of L1/L2-centric inter-cell mobility}
  + FFS: Whether to support activation of TCI states for more than one cells simultaneously
* The DL QCL and UL spatial relation rules already agreed for intra-cell scenario
* The use of SSB associated with a physical cell ID different from that of the serving cell as an indirect QCL reference for UE-dedicated PDCCH/PDSCH
  + Note: When RS X is an indirect QCL reference of a target channel, RS X serves as a QCL source RS of the source RS configured for the target channel.
  + FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL reference (source RS) for UE-dedicated PDCCH/PDSCH

Table 5 Additional inputs: issue 2 – Beam indication

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| **Company** | **Input** |
| Mod V0 | **The wording of proposal 2.1 has been quite stable from last round except for the following:**   1. **Joint vs separate TCI – raised by Nokia** 2. **The last bullet (note) was removed since it has caused confusion (pointed out by Huawei).**   **Please share your inputs, if any, on proposal 2.1** |
| Apple | We support current version. |
| OPPO | Suggest to add “at least for the case when the serving cell is not changed” because we are not sure what would be the impact if the serving cell is changed. When the serving cell is changed, both control plane and data plane need change, including the whole MAC entity.  **Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following at least for the case when the serving cell is not changed:  [Mod: We can check if this is agreeable to companies] |
| vivo | Support |
| Docomo | Support in general.  We are a bit confused with the following text. Is it correct understanding that 1)SSB with different cell ID can be direct QCL reference except for UE-dedicated PDCCH/PDSCH and 2)SSB with different cell ID can be used for indirect QCL reference for all cases (including UE-dedicated PDCCH/PDSCH)?   * The use of SSB associated with a physical cell ID different from that of the serving cell as a direct/indirect QCL reference, except for a direct QCL reference for UE-dedicated PDCCH/PDSCH   [Mod: Revised.] |
| LG | Support the current version |
| Mod V7 | **Revision** to remove confusion on SSB usage pointed out by Docomo.  **Please check OPPO’s comment** on adding “at least for the case when the serving cell is not changed” if it is agreeable.  **Please share your view on whether the support for separate TCI should be agreed in this meeting together with joint TCI, or it should be FFS for now**. |
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Measurement/reporting

**Conclusion 2.2**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP, there is no consensus on supporting the following RS types as measurement RS in RAN1#105-e

* CSI-RS for mobility/RRM associated with a non-serving cel
* CSI-RS for BM configured for a non-serving cell
* CSI-RS for tracking configured for a non-serving cell

**Proposal 2.3**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,

* Support at least K=4, where K is defined as the number of beams associated at least with non-serving cell(s) reported in a single CSI reporting instance
  + The maximum value of supported K is a UE capability
  + K is configured by NW based on the UE capability
  + FFS: The support of K=8 and 16
    - For K>4, the maximum number of beams associated with one cell is 4
* FFS: Support L1-based event-driven reporting based on Rel-16 SCell BFR framework, including the definition of L1-based event, if needed

Table 4 Additional inputs: issue 2 – measurement/reporting

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| **Company** | **Input** |
| Mod V0 | **Conclusion 2.2: Huawei pointed out that CSI-RS for BM and tracking should be reintroduced for this to be acceptable.**  **Proposal 2.3: The wording has been stable for a long time (no input)**  **Please provide your inputs, if any, on conclusion 2.2 and proposal 2.3** |
| Apple | Support in general, but we suggest some changes. I think they are editorial. We agree TRS should not be used for beam reporting, but it should be necessary for time/freq offset tracking.  I understand there are some concerns about the scope of event driven based beam report. Is it possible that we try to modify the last bullet of proposal 2.3 like “Support L1-based event-driven reporting based on SCell BFR framework, including the definition of L1-based event, if needed”, so that the scope can be smaller? We only need to define an event based on L1 measurement (This is related to RAN1 spec), and the reporting MAC CE content.  [Mod: Given the strong minority (yet valid) concern, this is a good step to reduce the scope of the FFS]  **Conclusion 2.2**: On Rel.17 multi-beam L1-RSRP measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP, there is no consensus on supporting the following RS types as measurement RS in RAN1#105-e   * CSI-RS for mobility/RRM associated with a non-serving cell * CSI-RS for BM configured for a non-serving cell * CSI-RS for tracking configured for a non-serving cell   **Proposal 2.3**: On Rel.17 multi-beam L1-RSRP measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * Support at least K=4, where K is defined as the number of beams associated at least with non-serving cell(s) reported in a single CSI reporting instance   + The maximum value of supported K is a UE capability   + K is configured by NW based on the UE capability   + FFS: The support of K=8 and 16     - For K>4, the maximum number of beams associated with one cell is 4 * FFS: Support L1-based event-driven reporting, including the definition of L1-based event, if needed   [Mod: Done] |
| OPPO | Support 2.2 and 2.3 |
| vivo | Support |
| Docomo | Support 2.2 and 2.3. |
| MediaTek | Support both proposals |
| Mod V7 | **Minor revision** per Apple’s comment |
|  |  |