**3GPP TSG-RAN WG4 Meeting # 102 -e R4-2206756**

**Electronic Meeting, 21st Feb– 3rd Mar, 2022**

**Agenda item:** 10.9.3.3

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for [102-e] [213] NR\_HST\_FR2\_RRM\_2

**Document for:** Information

# Introduction

This contribution will be used to guide and summarize the email discussion for the topic of Rel-17 NR HST FR2 enhancements RRM core requirements (AI 10.9.3.4) in RAN4 #102, with the email thread identifier “[102-e][213] NR\_HST\_FR2\_RRM\_2”.

This e-mail thread will capture the e-mail discussions for the following sub-agenda items for FR2 HST RRM

* AI 10.9.3.3 Timing requirements

In previous RAN4 meeting, WF on one shot large uplink timing adjustment has been approved

# Topic #1: Timing requirements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2203711](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_101-e/Docs/R4-2117302.zip) | Qualcomm | *Moderator note:* *3711 is submitted in the different agenda but part of proposals are related to uplink timing adjustment which is copied below for further discussions.*Proposal 2: Add a MAC-CE command to inform UE of the TCI state switch is across RRH and send an LS to RAN2.Observation 1: The proposed aperiodic L1-RSRP request can prevent false alarm and miss detection in large DL timing detection by enabling UE to use the updated SSB timing from the latest SSB occasion instead of stale SSB timing from SSB detection.Observation 2: The aperiodic L1-RSRP report approach for enabling large timing adjustment is more efficient than RACH procedure from throughput impact and network/UE implementation perspective.Proposal 3: Apply the following procedure to cross-RRH TCI state switch:* Network schedules an aperiodic L1-RSRP report to trigger DL timing difference detection before cross-RRH TCI state switch.
* RAN4 imposes UL and DL scheduling restriction after cross-RRH TCI state switch before first TRS reception. UE performs the large UL timing adjustment on the first UL transmission after the first TRS reception, and this timing adjustment is allowed to exceed the Tq requirement in 38.133 clause 7.1.2.1.

Observation 3: Propagation delay difference between two RRHs can cause large UL to DL interference when two UEs are close two each other and an RRH.Proposal 4: Network applies different offsets to DL frame boundaries of different RRHs to pre-compensate the propagation delay difference across different RRHs to eliminate UL to DL interference across UEs. Network then inform UE the TA change needed after TCI state change across RRHs |
| R4-2203754 | Apple | Proposal 1: Enable light weight inter-RRH signaling to UE. Proposal 2: Support network assisted information, i.e., enable network assisted signaling of SSB index and order per RRH.  For example:  * The signaling can reuse current SSB signaling by reinterpretation of the bit field when FR2 HST deployment flag is set.
* Group represent RRH, max 8 RRH per cell. SSB index is in order along the track.
* No additional signaling overhead.

Proposal 3: RAN4 can determine max number of RRH per cell supported in SIB1 signaling and leave detailed signaling design to RAN2. Proposal 4: Scheduling constraint of DL/UL reception/transmission follow TCI state switching delay.  |
| R4-2203899 | CATT | Proposal 1: For the value of timing difference threshold, we support option 3 with CP/4.Proposal 2: The UL scheduling restriction is necessary, when TCI is switched.  |
| R4-2205959 | Nokia | 1. An error in the UE transmit timing after large one-shot timing adjustment is directly dependent on the error in the UE evaluation of the DL timing, which is not limited by any existing requirement.
2. Immediately after large one-shot UL timing adjustment, the UE can transmit in UL with a timing error above Te.
3. RAN4 to prohibit UE transition immediately after large one-shot UL timing adjustment until the timing error (i.e., of the first transmission after the TCI state switch) is within Te.
4. If the UE needs to synchronize to any target beam after the TCI state switch to evaluate the DL timing difference in between the source and the target beams, then a systematic error above Te can be always present in the UE transmit timing after the TCI state switch, i.e., on the level of , where is an error in DL timing evolution.
5. The value of the threshold impacts the error in the UL transmit timing after the TCI state switch, especially if the timing difference is below the threshold. To avoid additional errors, it is preferred to select a lower threshold if the error in the DL timing evaluation is also low. For example, if DL timing is evaluated based on TRS with the error on the level of 10.7 ns, then the threshold can be around 3.5\*64\*Tc. However, if the error in DL timing evaluation is higher, e.g., on the level of 21.4 ns, then the threshold can be higher as well, e.g., as in Option 2: 4.5\*64\*Tc.
6. RAN4 to select a threshold on UE measurement of DL timing difference for triggering large one-shot UL timing adjustment on the level of 3.5\*64\*Tc = 115 ns.
7. Network signalling indicating inter-RRH TCI state switch to the UE can be beneficial to mitigate UL transmit timing error that appears due to a need to synchronize to the target beam in the case of intra-RRH TCI state switch.
8. RAN4 to introduce lightweight network signaling for the indication of inter-RRH TCI state switch to the UE, e.g., in the form of the one-bit flag in the TCI state switch command.
9. Use inter-RRH indication as a triggering condition for large one-shot UL timing adjustment.
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| R4-2204719 | Ericsson | Proposal 1: Support Option 2: Tq = 4.5\*64\*TC = CP/4.Proposal 2: UL performance degradation is expected before TRS is received after the TCI state switch, but no UL scheduling restriction is needed.  |
| R4-2204715 | Ericsson | Proposal 2: Support Option 3: Introduce inter-RRH indication, because of easy implementation. |
| R4-2205890 | Samsung | Proposal 1: For FR2 HST UE, it is dependent on UE implementation to perform SSB-based timing acquisition/tracking on the target SSB during Layer-1 SS-RSRP measurement before inter-RRH beam switching. Observation 1: For FR2 HST UE, if absolute DL timing difference before and after beam switching |Tp2 -Tp1| < CP/4 = 4.5\*64\*Tc, with UE’s autonomous timing adjustment (Tq = 4.5\*64\*Tc), UE’s uplink timing mismatch can be no larger than CP/2. Proposal 2: FR2 HST UE is allowed to perform one shot large UL timing adjustment only if UE identified the DL timing is changed with the magnitude larger than one fourth of OFDM symbol CP length, i.e., 4.5\*64\*Tc. Proposal 3: Support the proposal that the accuracy of one-shot timing adjustment is 4 times of DL timing estimation error. Observation 2: One more slot shall be allowed for interruption after TCI switching for FR2 HST scenario.Proposal 4: The DL interruption shall be accommodated in the RRM requirement for active TCI switching delay. Proposal 5: No need to consider DL scheduling restriction (until first TRS), because the current active TCI switching requirement already allow extra time for tracking if target TCI is not in the active TCI state list. Proposal 6: UL scheduling restriction (i.e., the UE is not expected to transmit PUCCH/PUSCH/SRS until the first TRS is received after the TCI state switch) is introduced for all TCI state switch.Proposal 7: The NW and UE behavior for FR2 HST scenario (in which one shot large UL timing adjustment is utilized) is illustrated in the flow-chart. Proposal 8: The text proposal is provided to introduce the requirement for one shot large UL timing adjustment.  |
| R4-2205008 | ZTE | Proposal 2: If only starting from RRM-1, we can not see strong request to introduce network assisted signalling. However in order to address the large propagation delay difference issue in RRM-2, we prefer Option 3 since the Uni-directional and bi-directional deployment flag has been approved. |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

Based on the submitted papers, different views have been observed on whether to introduce the inter-RRH indications.

Companies which prefer to introduce inter-RRH indication also proposed different signalling design approach, i.e., MAC-CE to indicate inter-RRH (Nokia, Qualcomm, Ericsson, ZTE) and SSB index and order per RRH (Apple, Ericsson). From operation procedure perspective, different procedure has been proposed.

Companies which prefer only rely on the timing difference threshold seems to have aligned threshold value which is CP/4 (CATT, Samsung) but different procedure has been proposed in Qualcomm paper (3711) and Samsung (5890)

From above observation, it is moderator understanding, the essential question to be answered is whether the inter-RRH indication is needed or not. The detailed procedure as well as signalling design can be further discussed assuming RAN4 will agree on either of introducing inter-RRH or not.

Meanwhile, it is also observed that three CRs have been proposed to introduce one shot large uplink timing adjustment.

* Nokia CR (4631) and Qualcomm CR (3713) based on inter-RRH indication
* Samsung CR (5892) based on no inter-RRH indication

To have more efficient discussion, moderator suggest to have parallel discussions assuming eventually RAN4 will agree on either to have inter-RRH indication or not to have inter-RRH indication. Therefore, moderator suggest to collect comments for all these three CRs in the 1st round. By doing that, it is expected corresponding CR could be ready for approval together with the decision on whether inter-RRH indication shall be introduced or not.

Also, companies proposed the considerations for scheduling restrictions. To have more focused discussions for above essential question, moderator suggest to skip this topic in the 1st round and open the discussions for scheduling restriction in the 2nd round.

Samsung propose the TP to TR on uplink timing adjustment in 5891. As similar as scheduling restriction, moderator suggest to skip comments on TP to TR in the 1st round and open the discussions in the 2nd round.

Based on above observation, moderator suggest to have the following sub topics for 1st rounds

* Sub topic 1-1: Whether to introduce inter-RRH indication?
* Sub topic 1-2: If RAN4 agree to introduce inter-RRH indication, what is the exact procedure for network to configure such inter-RRH indication
* Sub topic 1-3: If RAN4 agree NOT to introduce inter-RRH indication, what is the exact procedure for applying one shot large uplink timing adjustment
* Sub topic 1-4: Companies’ comments on the CR 4631 and 3713 assuming RAN4 will introduce inter-RRH indication
* Sub topic 1-5 Companies’ comments on the CR 5892 assuming RAN4 will NOT introduce inter-RRH indication

### Sub-topic 1-1: Inter-RRH indication

*Open issues and candidate options before e-meeting:*

* Whether to introduce inter-RRH indication?
	+ Option 1: Yes (Apple, Qualcomm, Nokia, Ericsson, ZTE)
	+ Option 2: No (CATT, Samsung)
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | The following agreements have been achieved in the Monday GTW session. * Inter-RRH indication
* Do not introduce explicit inter-RRH indication signalling for NR FR2 HST in Rel-17
* FR2 HST Inter-RRH indication signalling enhancement can be considered in Rel-18 subject to RAN plenary decision
* FFS whether additional assumptions for the definition one shot UL timing adjustment requirements shall be introduced (e.g., UE is configured with aperiodic L1-RSRP reporting before the TCI state switch, or UE performed fine time tracking with Xms before/after TCI state switching)

Based on above agreements, moderator suggest to close this sub-topic in 1st round and focus on the FFS part in the 1st round  |
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### Sub-topic 1-2: Detailed procedure with inter-RRH indication

*Sub-topic description*

* If RAN4 agree to introduce inter-RRH indication, what is the exact procedure for network to configure such inter-RRH indication
	+ Option 1: (Apple’s proposal in 3754)
	+ Option 2: (Nokia’s proposal in 5959)
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round
	+ To facilitate the discussions, proponents (Apple and Nokia) input on high level descriptions of procedure are required

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | Based on the GTW agreements, moderator suggest to close this sub topic in 1st round  |

### Sub-topic 1-3: Detailed procedure without inter-RRH indication

*Sub-topic description*

* If RAN4 agree NOT to introduce inter-RRH indication, what is the exact procedure for applying one shot large uplink timing adjustment
	+ Option 1: (Qualcomm’s proposal in 3711)

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| * Step 1: UE detect the timing difference before TCI state switch
	+ Network schedules an aperiodic L1-RSRP report before cross-RRH TCI state switch
	+ After receives the aperiodic L1-RSRP report, UE refines timing based on PSS/SSS and performs the detection on the next SSB measurement occasion for a set of candidate SSBs. Options for candidate SSBs
		- Option 1: Network configures one set in csi-SSB-ResourceSetList with the first x SSBs in each RRH that UE can switch to when switching to the RRH. Alternatively, network configures one set for each RRH in csi-SSB-ResourceSetList with the first x SSBs in the RRH that UE can switch to when switching to the RRH. csi-SSB-ResourceSet in CSI-AssociatedReportConfigInfo point to this set, and UE use it as candidate SSBs.
		- Option 2: x SSBs with the largest RSRPs reported previously
	+ Detection rule: any of the candidate SSBs satisfy |SSB timing – current DL timing|>threshold
		- If any of the candidate SSBs satisfies the condition, the next TCI state switch to that SSB is cross-RRH
* Step 2: UE adjust DL and UL timing after cross-RRH TCI state switch
	+ Apply DL/UL scheduling restriction after cross-RRH TCI state switch until the first TRS is received after the TCI state switch.
		- No DL and UL reception/transmission is scheduled before first TRS is received to prevent UE from receiving/transmitting signals based on the coarse timing from the SSB measurement.
	+ UE adjust DL timing by using coarse timing from the SSB measurement after the aperiodic L1-RSRP report, and refine the DL timing by the TRS received after TCI state switch
		- UE applies TA adjustment magnitude of 2\*|TRS timing – previous DL timing| on the first UL after TRS reception (UL TA adjustment is twice of DL timing change)
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* + Option 2: (Samsung’s proposal in 5890)

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* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | * Based on the GTW agreements below,
* Inter-RRH indication
* Do not introduce explicit inter-RRH indication signalling for NR FR2 HST in Rel-17
* FR2 HST Inter-RRH indication signalling enhancement can be considered in Rel-18 subject to RAN plenary decision
* FFS whether additional assumptions for the definition one shot UL timing adjustment requirements shall be introduced (e.g., UE is configured with aperiodic L1-RSRP reporting before the TCI state switch, or UE performed fine time tracking with Xms before/after TCI state switching)

Moderator suggest companies which suggest to perform fine time tracking within Xms before/after TCI state switching to provide detailed procedure descriptions as additional option. Meanwhile, companies comments on above procedure are expected in the 1st round.  |
| QC | First, we want to clarify that “fine time tracking within Xms” is not feasible as an UE requirement, since UE doesn’t know the TCI state switch timing before it receives the command. But with option 1, UE can achieve “coarse timing tracking within Xms” but X is determined by the timing network sends aperiodic L1-RSRP request and TCI state timing, and we suggest to leave it to network implementation.We addressed comments on option 1 received during GTW:1. Additional delay due to the aperiodic L1-RSRP request: the proposal is to refine SSB timing and detect large DL timing change after the L1-RSRP request. Hence the additional delay is one SSB period plus a few ms, if network schedules TCI state switch in time. SSB period is expected to be 20ms, and UE can only travel 2m within 20ms. No matter which scenario we considered, 2m can not lead to large SNR difference. Note that comparing to L1-RSRP periodic reporting delay, which is the major source of TCI state switch delay (network needs to receive the report to decide TCI state switch), typical Treport value is much larger than one SSB period. Furthermore, network can further optimize it if delay is a concern, e.g., send aperiodic L1-RSRP request when received L1-RSRP is close between serving and best target beams.2. Feasibility of network implementation: since TCI state switch is a network command, network has full control on when to send it, and adding one aperiodic L1-RSRP request before the switch command shouldn’t be an issue. 3. Feature/spec discussion: note that option 1 didn’t change the interpretation aperiodic L1-RSRP request as a standalone command. The requirement in option 1 is “When one shot large UL timing adjustment is enabled, UE is required to take additional actions after aperiodic L1-RSRP request”. Therefore, the procedure is defined corresponding to the one shot large UL timing adjustment enablement signaling, and aperiodic L1-RSRP request only provides a timing as a side information of this procedure. Regarding whether this procedure is considered as a new feature, according to our proposal, we support to consider this procedure as an optional feature, but the feature is the detection procedure and the aperiodic L1-RSRP request only serves as a side condition in this procedure. Option 2 is not feasible for UE, it effectively asking UE to (1) predict when TCI state switch can happen (2) predict which SSBs are the possible new TCI state. Even UE has an effective algorithm to do all these predictions, UE is required to include a lot measurement occasions and large number of SSBs to avoid missing any possible inter-RRH TCI state switch detection occasions. As we mentioned before in our contributions, UE has a lot of beam management/refinement procedures to execute, and adding both the prediction algorithm and timing tracking in many measurement occasions and many SSB indexes push out the processing resources for essential and indispensable beam management/refinement procedures. * If we compare option 1 with option 2, network has full information for (1) when inter-RRH TCI state switch can happen (2) which SSB index is the inter-RRH TCI state switch one. It is a more reasonable design to have network provide the information to UE by aperiodic L1-RSRP request which is an existing signaling procedure with entries to indicate necessary information instead of asking UE figures out all the information that network already has by itself. We already compromised not to introduce network assistant signaling, and this proposal leverages existing signaling while keeps all the existing functions of this signaling unchanged. Therefore, we see significant advantage of option 1 over option 2.
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| Apple | Here is the timeline for time/freq after TCI state switching. For UL timing adjustment, it is 2\*(T2-T1), where T1 is the DL timing measured at the last slot receiving from old TCI, T2 is the DL timing measured at the 1st slot receiving from the new TCI.  |
| ZTE | We believe Option 1 is some replacement since lack of inter-RRH indication. Once UE acquired the new DL timing, then UE can perform detection with the *offset = new DL timing - old DL timing* compared with threshold. So how and when to identify new DL timing is the key issue.For Option 1, we understand the acquirement of new DL timing was split into two steps: 1) Acquiring coarse new DL timing based on the SSB triggered by a-periodic L1-RSRP request. Since such SSB transmitted right before TCI state switching, so UE can receive the SSB based on old DL timing, and obtain coarse new DL timing based on them. Which complies with the UE procedure if timing update is necessary during TCI state switching process defined in current spec; 2) Acquiring fine new DL timing based on the TRS transmitted after TCI state switching so as to refine the coarse new DL timing acquired in step 1). Since a-periodic L1-RSRP request is an existing scheme, so no new signalling introduced by Option 1.For Option 2, since no special SSB transmitted to let UE identify new DL timing, so UE can only depend on the periodic SSB/CSI-RS to acquire new DL timing before TCI state switching, whether such SSB/CSI-RS are fresh enough, which should be considered. |
| Ericsson | Regarding moderator’s question ‘Moderator suggest companies which suggest to perform fine time tracking within Xms before/after TCI state switching to provide detailed procedure descriptions as additional option.’, it’s unclear to us what’s the actual definition of ‘fine time tracking’, e,g. SSB based or TRS based, and what’s the purpose, e.g. identify inter-RRH or determine exact UL timing adjustment. If the question is to determine UL timing adjustment (after TCI state switch), proposal 1 has explicit TRS delay compared to proposal 2, but proposal 2 needs TA command by network. The difference of effect on requirements may be delay by TRS delay or TA command, but it is possible to define a unified slot number of the delay. |
| Nokia | Even though it was agreed not to define any explicit network assistance signaling in Rel-17 for inter-RRH beam switch we still see obvious benefits in letting the UE know whether the beam switch is inter-RRH or intra-RRH, both from the delay and performance perspectives.As Option 2 does not consider such a possibility, it is not our preference.It seems that the goal of Option 1 is to provide to the UE additional information about inter-RRH TCI state switch and trigger target beam time tracking without explicit signaling.However, Option 1 challenge is the network impact as is it implies non-straightforward network implementation, as follows:* An aperiodic L1-RSRP report request needs to be sent **before** the TCI state switch is triggered by the NWTo enable this the NW needs to **pre-indicated** the TCI state switch. If the TCI state switch does not happen after the pre-indication, then the NW might need to send more requests. It is not trivial to define how to trigger pre-indication or how frequent those requests shall be. Moreover, several beams could be candidates for TCI state switch.
* An aperiodic RSRP report request needs to be sent **after** the TCI state switch (conditions) is triggered by the NW.In this case, sending aperiodic request will delay triggering of TCI state switch for the UE. It is not desirable because in some HST FR2 scenarios (e.g. when the train is moving opposite to the serving beam) the signal strength of the serving beam can degrade drastically during a short time.

Hence, this approach impacts the network in terms of adding additional steps to the basic TCI state switch procedure.In general, aperiodic RSRP could be beneficial for more accurate time tracking in the target beam, when this is needed. As a compromised solution we would like to propose more straightforward approach of allowing UE to known when a TCI state switch is an inter-RRH beam switching.**Option 3 (Active TCI sate list for inter-RRH indication)**1. In HST FR2 scenario NW adds to the active TCI state list for PDSCH of the UE only beams that are collocated to serving beam (intra-RRH).
2. When the UE receives a TCI state change and the target beam is in the active TCI state list (intra-RRH beams), then the UE can perform TCI state switch as currently, and no additional delay for synchronization in the target TCI state is needed (TOk in TCI state switch delay = 0)
3. When the UE receives a TCI state change and the target beam is not in the list (not an intra-RRH beam), then UE will be allowed more time for synchronization and time tracking after the TCI state change, i.e. for the TCI state switch, e.g., TOk = 1.

**This can be done without new signaling**. The whole package solution for UL timing in HST FR2 scenario is illustrated in the flow chart:Diagram  Description automatically generatedIf the UEs can track both source and target beams together, the additional TCI state switch delay can be avoided for such UEs. |
| QC | To address Ericsson’s comment:If network schedule cross-RRH TCI state switch close enough to the aperiodic L1-RSRP report, e.g., immediately after the SSB occasion, the timing from SSB is accurate enough to decode normal grants and transmit on UL , as long as channel condition is good and MCS is not extremely high. Therefore, we are open to discuss step 2 in our proposal, i.e., whether to impose scheduling restriction after cross-RRH TCI state switch. Since network knows how close the SSB occasion after aperiodic L1-RSRP request and cross-RRH TCI state switch is, it can determine what MCS/whether to schedule grants accordingly.  |
| Samsung | We would like to clarify more about option 2, especially considering the comments received on option 2: * As mentioned by QC, with option 1, UE can achieve “coarse timing tracking” by following the NW instructed inter-RRH SSBs by using a-periodic L1-RSRP report, which we agree that even with the implicit “inter-RRH” indication, UE can only have coarse timing information, if the corresponding TRS is not tracked. Then the problem will be “is that possible for UE to track other SSBs for coarse timing”. It should be noted that we assume NW shall configure periodic SSB-based L1-RSRP reporting for BM, and measurement shall anyway be performed.
* An reasonable UE implementation can be: based on L1 SS-RSRP measurement, if a SSB’s SS-RSRP level is increasing and comparable to serving SSB’s RSRP (e.g., XdB less than serving SSB), and then UE can assume that SSB could be the potential one to be switched to, so coarse timing will be performed on them. By having this implementation, the number of SSBs to be timing tracked will be reduced, which we hope can address companies’ concern on UE complexity.

For the option 1 & the new proposal from Nokia by reusing active TCI state list: * For option 1 and new proposal from Nokia, both can be regarded as a way to implicitly indicate inter-RRH beam switching from intra-RRH one.
* For Nokia’s active TCI state list, it may depends on UE capability, and if UE can only tracking one active TCI state, i.e., the serving SSB, then how to use that list to include all intra-RRH TCI states? Another case is if # of intra-RRH TCI states is larger than UE’s capability for active TCI states, similar problem will exist. If we can’t guarantee the MAC-CE activated PDSCH TCI state list contains all intra-RRH beams, this proposal will work just like option 2.
* Furthermore, with Nokia’s proposal, UE have no chance to track inter-RRH TCI state’s fine timing, in other words, TOk = 1 always happens, even if UE has the capability to track the inter-RRH TCI state. If that is the case, seems it is an optimization to lower down system performance. If above concerns about Nokia’s new proposal can be solved, we are open to discuss the details, especially how this mechanism impact the condition of RRM requirement for one shot large timing adjustment.
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| QC | A few additional comments:We found that we keep using fine timing and coarse timing, but companies may have different interpretation of what it means, and we want to clarify ours.Coarse timing tracking: based on sequence correlation, can find the strongest path, but may not be able to maximize received powerFine timing tracking: consider multiple path and maximize received power, need to have coarse timing from sequence detection without too much driftAnd with the coarse timing before TCI state switch, UE can actually perform fine timing tracking on the first SSB after TCI state switching within TCI state switch delay. Therefore, we want to slightly clarify that SSB based fine timing is available with option 1 after TCI state switch delay in cross-RRH case, while methods involving acquiring timing after TCI state without coarse timing (not with a large drift) can’t perform fine timing tracking, and performance degradation on the Tx/Rx after first SSB after cross-RRH TCI state switch might be expected. |

### Sub-topic 1-4: Comments on the CR 4631 assuming RAN4 will introduce inter-RRH indication

*Sub-topic description*

* Comments on CR 4631 assuming RAN4 will introduce inter-RRH indication
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderators | Moderator suggest to close this sub topics based on GTW session agreements.  |
| Nokia | Our Draft CR is not fully based on the assumption that RAN4 introduces inter-RRH indication.The only related part is[the UE is indicated about the inter-RRH TCI state switch]which is in the square brackets. And if our Option 3 above is areeable then it is till relevant.Morover, we also have a change request for the section 7.1.2.1 Gradual timing adjustment.Therefore, we cannot agree that our draftCR shall be excluded from the discussion completely.Even more, we propose our draftCR to be used as a baseline because it describes the whole package soltuion and the Timing requiremnts section is allocated to Nokia following the CR work split. |

### Sub-topic 1-5: Comments on the CR 5892 and 3713 assuming RAN4 will NOT introduce inter-RRH indication

*Sub-topic description*

* Comments on CR 5892 and 3713 assuming RAN4 will not introduce inter-RRH indication
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | Moderator suggest companies continually provide comments/suggestions for the above two CRs  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

In GTW session, the following agreements achieved

* Inter-RRH indication
* Do not introduce explicit inter-RRH indication signalling for NR FR2 HST in Rel-17
* FR2 HST Inter-RRH indication signalling enhancement can be considered in Rel-18 subject to RAN plenary decision
* FFS whether additional assumptions for the definition one shot UL timing adjustment requirements shall be introduced (e.g., UE is configured with aperiodic L1-RSRP reporting before the TCI state switch, or UE performed fine time tracking with Xms before/after TCI state switching)

Based on above agreements, sub topic #1-1, 1-2 and 1-4 can be closed.

First of all, about the “UE perform fine time tracking with Xms before/after TCI state switching” part in FFS sub-bullet, based on the comments received, it is moderator understanding it just further describes how the downlink timing different is derived based on aperiodic L1-RSRP configuration approach.

Furthermore, during the 1st round e-mail discussion, Nokia has proposed new option to implicitly indicate inter-RRH, .i.e., Active TCI sate list for inter-RRH indication.

For option 2, UE complexity and feasibility issue of predicting TCI switching and finding the potential RS resource (SSB) for target TCI to perform timing tracking is raised and clarified.

On the other hand, the drawback of additional delay caused by additional aperiodic L1-RSRP measurement in option 1 and unknown TCI switching in Nokia option was raised. Further clarifications for above issues are expected.

Therefore, as wayforward for 2nd round e-mail discussions, Moderator suggest the following bullets

* RAN4 will further decide one of the following approaches as additional assumptions for applying one shot UL timing adjustment
	+ Option 1: Implicit inter-RRH indication based approach
		- Option 1a: Aperiodic L1-RSRP based approach (QC)
		- Option 1b: Active TCI list based approach (Nokia)
	+ Option 2: UE detection based approach without any implicit inter-RRH indication (Samsung)
* Companies which support each above options are supposed to reach consensus on relative CRs, i.e.,
	+ CR 3713 for option 1a
	+ CR 4631 for option 1b
	+ CR 5892 for option 2.

BAsed on above moderator suggestions, moderator also suggest to continue collect comments for first main bullet in this e-mail thread and provide the direct revised suggestions for the CRs in CR draft folder

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| **Sub-topic** | **Status summary**  |
| **Sub-topic #1-1** | Follow GTW agreements |
| **Sub-topic #1-2** | Follow GTW agreements |
| **Sub-topic #1-3** | * RAN4 will further decide one of the following approaches as additional assumptions for applying one shot UL timing adjustment
	+ Option 1: Implicit inter-RRH indication based approach
		- Option 1a: Aperiodic L1-RSRP based approach
		- Option 1b: Active TCI list based approach
	+ Option 2: UE detectionbased approach without any implicit inter-RRH indication
 |
| **Sub-topic #1-4** | Follow GTW agreements |
| **Sub-topic #1-5** | Further revise CRsCompanies which support each above options are supposed to reach consensus on relative CRs, i.e., * CR 3713 for option 1a
* CR 4631 for option 1b
* CR 5892 for option 2.
 |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
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| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| R4-2203713 | To be revised  |
| R4-2204631 | To be revised |
| R4-2205892 | To be revised |

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## Summary on 2nd round

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
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| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round

* RAN4 will further decide one of the following approaches as additional assumptions for applying one shot UL timing adjustment
	+ Option 1: Implicit inter-RRH indication based approach
		- Option 1a: Aperiodic L1-RSRP based approach
		- Option 1b: Active TCI list based approach
	+ Option 2: UE detection based approach without any implicit inter-RRH indication
* Recommended WF
	+ Companies are invited to provide the comments/preference to above options in the 2nd round

Companies views’ collection for 2nd round

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| Company | Comments |
| Moderator | Moderator suggest to provide the comments for both solution and corresponding CRs in 2nd round, e.g., If you prefer option 1a, please also provide the comments on corresponding CR (3713 for option 1a) For comments on corresponding CRs, companies can either provide the comments in e-mail discussion or directly revise the CR in the 2nd round draft CR folder  |
| QC | Option 1a is proposed for UEs supporting only one active TCI state.For UEs supporting multiple active TCI states, we can support the following requirement modified from option 1b:**When UE supports more than one active TCI state, the legacy TCI state switch requirement applies to cross-RRH TCI state switch when the TCI state from the new RRH is in the active TCI state list.**To us the above requirement is quite straightforward, and we suggest to treat UE supporting multiple active TCI states and single active TCI state separately, and making agreement on multiple active TCI states first.For single active TCI state UE, we still support option 1a because we see issues in option 2 as explained below:For option 2, we reviewed Samsung’s comment, it requires UE to predict TCI state switch timing and the associated SSB index. However, we thought that TCI state switch is a network initiated command instead of UE initiated one because 3GPP communities believe network has to complete information to do it instead of UE. Without successfully predict TCI state switch timing and the associated SSB index, UE has to blindly perform the timing refinement and large timing difference detections in many measurement occasions, and we already explained that this squeezes out the resource for beam management and refinement, not feasible for UE to maintain demod/BM performance and supporting option 2 simultaneously. |
| QC2 | We further analyze Apple’s comment in the first round below:If coarse timing (PSS detection based) is done after TCI state switch, one additional RS (SSB or TRS) is needed after the first SSB as in legacy TCI state switch. Therefore, we can compare the event sequence based on Apple’s comment and option 1a:

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|  | Option 1 cross-RRH NW action | UE action | Option 1 intra-RRH NW action | UE action | Scheme based on Apple’s comment NW action (for both cross and intra RRH) | UE action |
| Event 1 | NW decides to switch to a cross-RRH TCI state, NW sends AP L1-RSRP report | UE receives in old TCI state | NW decides to switch to a cross-RRH TCI state, NW sends TCI state switch command | UE receives in old TCI state | NW decides to switch to a cross-RRH TCI state, NW sends TCI state switch command | UE receives in old TCI state |
| Event 2 | NW sends an SSB, and sends the TCI state switch command | UE receives in old TCI state for 22ms | NW sends the first SSB (+ processing time) | UE can start to communicate after 22ms | NW sends the first SSB (+ processing time) | UE can’t receive anything in 22ms |
| Event 3 | NW sends the first SSB (+ processing time) | UE can start to communicate after 22ms |  |  | NW sends the second RS (+ processing time) | UE can start to communicate after 22ms |

By comparing option 1a with the scheme based on Apple’s comment (called option 3 below):1. When comparing to option 1a intra-RRH case, there is additional 22ms delay in option 3
2. When comparing to option 1a cross-RRH case, UE stay additional 20ms in old TCI state but is able to communicate with old TCI state. However, option 3 introduces 22ms additional delay in which UE can’t communicate

Therefore, we see in both cases, option 1a offers a better performance. Given option 3 requires 44ms TCI state switch delay and might be slower than RACH if we consider CFRA as Nokia suggested. Note that RACH introduces delay only in cross-RRH TCI state switch, while option 3 introduces delay in both cross and intra-RRH TCI state switch. Given that option 3 introduces one additional RS (TRS or SSB) delay for intra-RRH TCI state switch and one SSB plus one RS (SSB or TRS) delay for inter-RRH when compared to RACH procedure, then if there are *x* intra-RRH TCI state switch in on RRH, as long as*x\*(Trs+TSSB-proc)+(Tfirs-SSB+TSSB-proc+Trs+TSSB-proc)> CFRA delay*Network should disable one shot timing adjustment and schedule a CFRA after cross-RRH TCI state switch instead. The total additional delay on LFS is in the order of 100ms when 3 to 4 TCI state is considered, and a CFRA session in close to RRH area with a good L1-RSRP report already (meaning UE increasing PRACH power is not expected) should be shorter.We suggest to agree on option 1a, and if network doesn’t want to implement option 1a, it can disable one shot large timing and go for the RACH solution. |
| Apple | When UE only support one active TCI state, then one SSB will always be used after TCI state switching for time/freq sync. When UE support two or more active TCI state, then the implicit TCI state can be used. Number of SSBs required depends on SINR range. Before TCI state switching command, UE maintain rough timing for L1-RSRP measurement purpose. With 1 SSB sync after TCI state switching, depends on SNR range, proper PDCCH and PDSCH scheduling is needed.Issue with approach 1a is there is no network guarantee of the nice sequence ap L1-RSRP triggering - > SSB -> TCI state switching.  |
| Nokia, Nokia Shanghai Bell | Following the comments from different companies, we can observe that there are at least three possible UE types:1. **Type-1**: UEs that have only one active TCI and cannot track coarse timing for the target TCI states
2. **Type-2:** UEs that can track course timing to the target TCI states.
3. **Type-3**: UEs that are capable to track fine timing for the multiple TCI state in active TCI state list.

Consequently, the TCI state switching delay for these UE categories will be different:1. Type 1 UEs need 1 SSB to establish coarse sync to the target beam and another RS for fine synch
2. Type 2 UEs need 1 RS to establish fine sych after the TCI state switch
3. Type 3 UE does not need additional RSs after the TCI state switch

Hence, the TCI state switching delay can, in general, be described with the following new clause in TS 38.133 (TOct stands for the time needed to acquire *coarse timing*):8.10.x MAC-CE based TCI state switch delay for FR2 HST scenariosIf the target TCI state is known, upon receiving PDSCH carrying MAC-CE activation command in slot n, UE shall be able to receive PDCCH with target TCI state of the serving cell on which TCI state switch occurs at the first slot that is afterslot n+ THARQ + + TOct\*(Tfirst-SSB + TSSB-proc) / *NR slot length* + TOk\*(Trs + Trs-proc) / *NR slot length*.The UE shall be able to receive PDCCH with the old TCI state until slot n+ THARQ + . Where THARQ is the timing between DL data transmission and acknowledgement as specified in TS 38.213 [3]; -    Tfirst-SSB is time to first SSB transmission after MAC CE command is decoded by the UE;-    Trs is time to the first RS transmission either following the first SSB transmission or after MAC CE command is decoded by the UE;-    TSSB-proc = 2 ms; -    Trs-proc = 2 ms;-    TOct = 1 if target TCI state is not in the active TCI state list for PDSCH *[Type -1 UE]*, or UE is not capable to track coarse timing of target TCI, 0 otherwise *[Type-2 and Type-3 UE]*;-    TOk = 1 if target TCI state is not in the active TCI state list for PDSCH *[Type-1 and Type-2 UEs]*, 0 otherwise *[Type-3 UEs].*The open question in this proposal is how to distinguish Type-2 UEs. One way would be to define such a UE capability.Regarding the Option 1 from the first round, we still do not prefer to introduce a new TCI state switching procedure that involves transmission of aperiodic L1-RSRP request before the TCI state switch for several reasons:* The network impact of this procedure is not negligible
* The solution can be considered as an optimization to special type of UEs, i.e., Type-1 UEs above. However, this is already a solution in 3GPP for this issues, i.e., utilization of multiple active TCI states.
* Finally, such a new mechanism will not be needed if NWA signaling for inter-RRH TCI state switch indication is introduced in Rel-18.

We also want to highlight several aspects in UL timing adjustment requirements for HST FR2 that are related to the TCI state switch:* It is necessary to define the time when large one-shot timing adjustment is over. Otherwise the NW does not have information when it can schedule UL again.
* It is necessary define requirements both when largeOneStepUL-timingFR2-r17 is enabled or not.

The corresponding new clause in TS 38.133 is proposed below:7.1.2.3 UL timing adjustment for FR2 HST scenarios When [*largeOneStepUL-timingFR2-r17*] is enabled for UE suppporting FR2 power class 6, the UE shall apply one shot large UL timing adjustment if the absolute value of the DL timing difference exceeds [*FFS*] during TCI state switching. The value of the one shot large UL timing adjustment applied by the UE shall be , where - (in units) is the DL timing defined as the time when UE receives downlink frame with new TCI state. - (in units) is the DL timing defined as the time when UE receives downlink frame with old TCI state.The UE transmission timing error after the one shot UL timing adjustment shall be less than or equal to Te defined in Table 7.1.2-1 no later than [x] after the TCI state switch delay.UE transmit power shall be turned off until initial transmission timing error is less than or equal to Te where the timing error limit value Te is specified in Table 7.1.2-1.When [*largeOneStepUL-timingFR2-r17*] is not enabled, then UE transmit power shall be turned off except for PRACH transmission or message A transmission until UE has acquired UL timing.We are open to further discussion of the proposals above. |
| Samsung | For active TCI switching delay requirement, we think the newly proposal from Nokia can be the one to be based for further discussion. We agree with Nokia’s comments above. Beyond that, we think it is hard to define a condition (e.g., within X ms, UE performed an aperiodic L1-RSRP measurement reporting).To summarize option 1 (Qualcomm) and 2 (Samsung), and the new proposal from Nokia:

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|  | When to perform fine timing tracking for target TCI state | How UE know target TCI state before TCI state switching command | PDCCH transmission in old TCI state  | PDCCH transmission in new TCI state, if new TCI state is NOT in active TCI state list (TOk = 1) | PDCCH transmission in new TCI state, if new TCI state is in active TCI state list (TOk = 0) |
| Option 1 (Qualcomm) | Before TCI state switching command | NW implicit indication (aperiodic L1-RSRP) | No change from Rel-15(till n+ THARQ + ) | No change from Rel-15(till n+ THARQ + + TOk\*(Trs + Trs-proc) / *NR slot length*) | No change from Rel-15 (except potential one symbol/slot more delay) |
| Option 2 (Samsung) | Before TCI state switching command | UE implementation-based,  | No change from Rel-15(till n+ THARQ + + TOk\*(Trs + Trs-proc) / *NR slot length*) |
| Option 3 (Nokia, new proposal) | After TCI state switching command | Not needed | Longer time allowed for UE: (after n+ THARQ + + TOct\*(Tfirst-SSB + TSSB-proc) / *NR slot length* + TOk\*(Trs + Trs-proc) / *NR slot length*)Where TOk = TOct = 1 |

Firstly, for Nokia’s proposal, we prefer a simplified one, in which no need to discriminate different “UE types”. Note: in RF session, UE type is a defined concept related to UE application scenario and form factor. * For Option 2, I think Sean has questioned about the impact to UE implementation.
* For Option 1, from both Samsung and Nokia have concerns on introducing additional aperiodic L1-RSRP reporting for NW.
* For Option 3, seems Sean has concern on the number of slots for which UE is not expected to receive PDCCH.

Seems Option 3 can be a compromised solution we can follow, while the NW indication can be introduced in Rel-18 as the enhancement to decrease the delay. For CR on one shot large UL timing adjustment, seems our and Nokia’s proposed text are approaching. Here are the revisions to address the concern: <<Start of Change>>One shot large UL timing adjustment for FR2 Power Class 6 UEFor FR2 power class 6 UE configured with IE *[highSpeedOneShotLargeULTimingAdjustmentFR2Flag]*, when UE is required to perform TCI state switching and the magnitude of the DL timing difference ΔT exceeds the threshold H, the UE shall adjust its transmission timing in one shot large UL timing adjustment, provided that the following side condition is met. Otherwise when the magnitude of the DL timing difference ΔT ≤ H, the UE shall adjust its transmission timing according to the requirement specified in clause 7.1.2.1. The magnitude of DL timing difference is defined as , where- T1 is the current DL timing before applying the one shot large UL timing adjustment,- T2 is the DL timing derived from the reference signals associated with the target TCI state.The threshold H is [4.5\*64\*Tc], and the side condition is- The SSB and corresponding reference signal associated with the target TCI state remain detectable during the TCI switching period. For the first UL transmission after the one shot large UL timing adjustment, the requirement specified in clause 7.1.2.1 is not applicable. The UE transmit timing immediately after applying the one shot UL timing adjustment shall be . After applying the one shot large timing adjustment on the first UL transmission, the UE shall perform the gradual timing adjustment by following the requirement specified in clause 7.1.2.1.<<End of Change>>For the following three bullets (copied from Nokis’s proposal), we are open to discuss, but have the following comments: The UE transmission timing error after the one shot UL timing adjustment shall be less than or equal to Te defined in Table 7.1.2-1 no later than [x] after the TCI state switch delay.UE transmit power shall be turned off until initial transmission timing error is less than or equal to Te where the timing error limit value Te is specified in Table 7.1.2-1.[Samsung] Te is introduced for initial transmission timing. If Nokia’s proposal on TCI state switching delay is acceptable, we expect UE transmission timing error Te can be satisfied even in the 1st transmission on new TCI state. When [*largeOneStepUL-timingFR2-r17*] is not enabled, then UE transmit power shall be turned off except for PRACH transmission or message A transmission until UE has acquired UL timing.[Samsung] If one shot timing adjustment is disabled, we don’t have to trigger PRACH for every TCI switching, e.g., for intra-RRH switching, PRACH is not necessary. If so, why UE is required to perform PRACH? UL scheduling and PRACH (triggered by PDCCH order) is all controlled by NW, we don’t see this bullet is needed. Furthermore, “until UE has acquired UL timing” is not a clear UE behaviour for the spec.  |
| Moderator | New option has been discussed in the 2nd round by allowing additional TCI switching delay for UE to perform fine downlink timing tracking. It is moderator observation, such proposal has been supported by Samsung and Nokia. It is expected GTW session will further narrow down the options between these two options - Option 1; Implicit inter-RRH indication by configuring aperiodic L1—RSRP measurement - Option 2: Introducing additional TCI switching delay for UE to perform fine downlink timing tracking Once RAN4 conclude either of above options for downlink timing tracking, it is moderator observation, RAN4 can further confirm the threshold used to trigger the one shot large timing adjustment. The tentative agreement can be 4.5\*64\*TcOn accuracy requirements of one shot uplink timing adjustment, Moderator proposed to consider 4 times of DL timing estimation error. Furthermore, scheduling restriction shall be also introduced based on the options chosen for downlink timing tracking. In summary, Moderator suggest to consider the following agreements as starting point of GTW session - RAN4 will further decide the following options for UE to perform downlink timing tracking - Option 1; Implicit inter-RRH indication by configuring aperiodic L1—RSRP measurement - Option 2: Introducing additional TCI switching delay for UE to perform fine downlink timing tracking - RAN4 will further decide to introduce scheduling restriction based on decision of above options of downlink timing tracking- FR2 HST UE is allowed to perform one shot large UL timing adjustment only if UE identified the DL timing is changed with the magnitude larger than one fourth of OFDM symbol CP length, i.e., 4.5\*64\*Tc. - The accuracy of one-shot timing adjustment is 4 times of DL timing estimation error.-  |
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# Recommendations for Tdocs

## 1st round

**Existing tdocs**

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| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| [R4-2203713](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203713.zip) | Draft CR to introduce one shot large UL timing adjustment for FR2 HST UE | [Qualcomm](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2203713.zip) | To be revised |  |
| [R4-2204631](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2204631.zip) | CR to TS 38.133: Tq timing adjustment requirements for FR2 NR HST | Nokia | To be revised |  |
| [R4-2205892](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205892.zip) | Draft CR to introduce one shot large UL timing adjustment for FR2 HST UE | Samsung | To be revised |  |
| [R4-2205891](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_102-e/Docs/R4-2205891.zip) | TP to TR 38.854 on RA-based UL Timing Adjustment for FR2 HST | Samsung | To be revised |  |

## 2nd round

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| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
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# Annex

Contact information

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Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)