**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-210XXXX**

**Electronic Meeting, 12th – 20th April, 2021**

**Agenda item:** 8.7.2, 8.7.5

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for [98-bis-e][322] NR\_HST\_FR2\_Scenarios\_Demod

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

In RAN Plenary #89-e, the RAN4-led work item of NR support for high speed train (HST) scenario in FR2 has been approved [RP-202118] (which has been further revised to [RP-210800] with editorial revisions and updates on time schedule).

Based on the agreement captured in WF [R4-2103240], companies are encouraged to further study the FR2 HST deployment scenarios and the feasibility study of supported maximum speed from demodulation perspective. Furthermore, from this meeting, the performance part on demodulation will be started based on the WID TU planning and work item planning.

In this email thread, the following agenda items will be discussed:

* 8.7.2 High speed train deployment scenario in FR2
* 8.7.5 Demodulation requirements

*List of candidate target of email discussion for 1st round and 2nd round*

* 1st round: TBA
* 2nd round: TBA

It is suggested to have the following target of 1st and 2nd round email discussion:

* 1st round: Further discussion on the deployment scenarios and demodulation related issues and requirements.
* 2nd round: Based on results from 1st round, achieve agreements as much as possible for deployment scenarios and demodulation related issues and requirements, as the basis for future discussion.

# Topic #1: Analysis on FR2 HST Deployment Scenarios

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2106825 | Huawei, HiSilicon | Observation 1: The minimum beam dwelling time can be 160 ms under HST FR2 scenario.Proposal 1: Assume 1 CPE per train as baseline for HST FR2 scenario.Proposal 2: Do not introduce any signaling for Bi-directional deployment for HST FR2 in Rel-17. |
| R4-2104905 | Qualcomm, Inc. | Proposal 1: Set UE antenna parameters the same as RRH except N=8, M=4 in simulation assumptions.Proposal 2: For the uni-directional model, the RRH boresight in azimuthal angle points to 780m from the projection of the RRH on the track.Proposal 3: For the uni-directional model, use one RRH beam for scenario 1 (Dmin = 10m). Proposal 4: For the uni-directional model, add an additional panel to the second and second last RRHs in a BBU to cover the HO region when Dmin is small. Define a network signaling to inform UE the presence of the additional panels.Proposal 5: For the bi-directional model, the RRH boresight in azimuthal angle points to 780m from the projection of the RRH on the track.Observation 1: Comparison of uni-directional and bi-directional models are listed in the following table:

|  |  |  |
| --- | --- | --- |
|  | Uni-directional | Bi-directional |
| Boresight direction | Ds+Dadd | (1) Ds+Dadd (2) Ds/2Our analysis suggests (1) to ensure coverage |
| Beam management | Each RRH covers [Dadd,Ds+Dadd] region, one region | Each RRH covers (1) [-Ds/2,-Dadd], [Dadd,Ds/2] and [Ds-Dadd, Ds+Dadd] three noncontiguous regions(2) [-Ds, -Ds+Dadd], [-Ds/2,-Dadd], [Dadd,Ds/2] and [Ds-Dadd, Ds] four noncontiguous regions |
| Throughput | About 10% worse than bi-directional model | About 10% gain over uni-directional channel |
| Handover | One additional panel is needed for some RRHs | No additional panel is needed. |
| Doppler spread (Dp = fc\*v/speed of light) | 0 if single path, <Dp if mult-path is considered | 2\*Dp if signal is received from two RRHs closest to UE on opposite side |

 |
| R4-2104679 | Ericsson | Observation 1: In scenario 1, DPS with a single TX beam and a single RX beam is sufficient to achieve coverage.Observation 2: There is no need or benefit from JT in scenario 1.Observation 3: There is no benefit from bi-directional deployment in scenario 1.Observation 4: For 350km/h scenarios, track curvature is not sharp and coverage can be provided with 1 TX/RX beam also for curves with 700m BS separation.Observation 5: For 120km/h scenario, curves may in some cases be sharper. Coverage with 1TX/RX beam for the most extreme curves can be provided if BS are spaced around 400m around the curve. (Alternatively, multiple beams could be used). |
| R4-2104924 | ZTE Corporation | Observation 1: For bi-directional situation, CPE need to tackle the doppler shift hopping from minus to plus or plus to minus.Proposal 1: The ability of multi-beam Rx or Tx at a time can be considered for CPE under uni-directional situation of scenario-A.Proposal 2: Multiple panels per CPE can be considered for bi-directional situation of scenario-A. |
| R4-2105023 | Samsung | Observation 1: For uni-directional RRH deployment in Scenario-A, even with single narrow analog beam per RRH panel (i.e., [Mg, Ng, M, N, P]=[1, 1, 8, 16, 2]), there is still 30dB margin compared against PC4 REFSENS requirement. Observation 2: For uni-directional RRH deployment in Scenario-A, with one additional beam used per RRH panel, the cellular coverage for the beam’s intended region can be improved, even with one fixed RX beam used in UE side. Observation 3: For uni-directional RRH deployment for Scenario-A, the beam dwelling time can be in the range of [0.45, 0.96] seconds for UE maximum speed of 350kmph.Observation 4: To solve the issue of coverage hole for bi-directional deployment, there are two possible schemes: - Scheme-1: Connecting to 2nd-Nearest RRH;- Scheme-2: Connecting to Nearest RRH except Coverage Hole. Observation 5: If Scheme-1 for bi-directional deployment is adopted for Scenario-A, there is no benefit compared with uni-directional counterpart. Observation 6: Scheme-2 for bi-directional deployment can be used for solve the coverage-hole issue, at the expense of 3 TX beam switching within each Ds. Observation 7: For bi-directional RRH deployment for Scenario-A, the beam dwelling time can be in the range of [0.80, 1.99] seconds for UE maximum speed of 350kmph. |
| R4-2106503 | Intel Corporation | Observation 1: For Scenario A single fixed TX beam per RRH panel is enough for sufficient link budget Observation 2: Multiple TX beams at the RRH should be considered for Scenario BObservation 3: Either Network or CPE (or both) should support bidirectional operation to ensure service for trains moving in different directions.Observation 4: Single panel at the CPE covering both directions leads to non-optimal antenna gain exploitation on the most part of the distance.Proposal 1: RAN4 to consider CPE to be equipped with two panels pointed in opposite directionsObservation 5: MU operation requires bidirectional deployment and DPS transmissionObservation 6: No impact of MU operation on the RAN4 requirements identified. Proposal 2: RAN4 requirement can be defined based on the baseline of 1 CPE device per trainProposal 3: RAN4 to focus only on DPS transmission mode for FR2 HST.  |
| R4-2106693 | Nokia, Nokia Shanghai Bell | On network deployment in Scenario-A:Observation 1: In Scenario A, the network covers mainly the area very close to the railway track.Proposal 1: RAN4 to use only one beam (i.e., one TCI state) per RRH in HST FR2 deployment Scenario A.Observation 2: For both bi- and uni-directional deployments, the discussed number of RRH sites per BBU is 4, i.e., only multi-RRH deployments are discussed. However, relatively large inter-RRH distance (Ds) makes a regular deployment with one RRH site per cell feasible. The mobility in this case is provided with the HO procedure.Proposal 2: RAN4 to consider also regular (non-SFN/non-DPS) deployment with 1 RRH site per BBU.Observation 3: In uni-directional deployments, it can also be sufficient to deploy only one RRH per RRH sight if CPE is capable of communicating with the network from opposite directions.Proposal 3: RAN4 to modify NOTE2 on the number of RRHs per sight in uni-directional deployment as follows:RAN4 focuses on 1 direction 1 train, but we are aware of the fact that either another panel to serve train towards the other direction is needed or a CPE is capable of Rx and Tx from the opposite direction. If this opposite direction is completely symmetric, the 1 direction study can apply directly.Observation 4: In regular (non-SFN/non-DPS) deployment, the beams' change happens together with the change of the RRH through the L3 HO procedure, which includes the synchronization to a target cell. Thus, the problem with different propagation delays when the CPE is switching serving RRH does not exist. However, the implications of different propagation delays can be experienced in Full SFN and DPS settings when the beams belong to the same cell, come from the same direction but from the different RRH sites. Such a situation can be observed both in uni- and bi-directional settings.Proposal 4: RAN4 to elaborate further on which deployments and propagation schemes are exposed to the very different propagation delays. Then, quantitively evaluate the implications in these scenarios both from the demodulation and RRM perspectives.Observation 5: The connection quality next to the RRH site in bi-directional deployment of Scenario A can be potentially improved by the signals coming from the neighboring RRHs. If it is the case, the Full-SFN scheme (i.e., PDSCH combining) can provide benefits.Proposal 5: RAN4 to discuss further if the connection quality in the area next to the RRH site in bi-directional deployment of Scenario A can be improved by switching to the reception from the neighboring RRH sites, e.g., using SFN or DPS schemes.On CPE configurations:Proposal 6: RAN4 to assume that in HST FR2 Scenario A, only high-speed CPEs installed on the roof of the train can be present in the network.Observation 6: We are not expecting any abnormal impacts on the system capacity or the inter-CPE interference when multiple CPEs per train are used.RAN4 requirements are formulated only for a single CPE/UE.Proposal 7: RAN4 to define requirements based on the assumption of 1 CPE per train.Observation 7: The utilization of only one panel pointing to the upside is less efficient in HST FR2 Scenario A in comparison to two panels per CPE oriented in opposite directions. However, we have not observed any mobility problem in this setting either, even though in our analysis, only one beam cooriented with the panel boresight was used.Proposal 8: RAN4 to decide if further analysis is needed regarding one panel per CPE pointing to upside and having analog beams directed to forward and backward in HST FR2 Scenario A.Observation 8: Uni- and bi-directional deployments can be mixed even in the same network.Proposal 9: If found to be needed, RAN4 to continue the discussion of issues related to the deployment type and UE capabilities signaling in the RRM track. |
| R4-2106826 | Huawei, HiSilicon | Observation 1: There is no any coverage issue under HST FR2 scenario assuming PC4 for both uplink and downlink.Proposal 1: Not consider Bi-directional deployment for Scenario A (700m/10m).Proposal 2: Use boresight parallel to the railway for Uni-directional deployment for Scenario A. |
| R4-2104680 | Ericsson | Observation 1: Scenario 2 can be adequately covered with 1 BS and 1 UE beamObservation 2: The coverage can be improved slightly using 2-3 BS beams and 1-2 UE beamsObservation 3: Bi-directional deployment is inferior to uni-directional deployment for scenario 2.Observation 4: JT is not useful for scenario 2Observation 5: For 350km/h scenarios, track curvature is not sharp and coverage can be provided with 1-3 TX/RX beam also for curves with 700m BS separation.Observation 6: For the 120km/h and low speed scenarios, closer spacing of the BS does not assist in the curve scenario and more beams may be needed.Proposal 1: RAN4 should confirm whether the 120 km/h curve scenario is important to investigate further for FR2 HST. |
| R4-2104926 | ZTE Corporation | Observation 1: If wider beam is considered for uni-directional situation of scenario-B, the number of TCI can be very small, e.g. 4.Observation 2: If wider beam is considered for bi-directional situation of scenario-B, the number of TCI can be very small, e.g. 4.Proposal 1: The ability of multi-beam Rx or Tx at a time should be considered for CPE under uni-directional situation of scenario-B.Proposal 2：To consider 4 TCIs for scenario-B of HST FR2.Proposal 3: Multiple panels per CPE should be considered for bi-directional situation of scenario-B. |
| R4-2105024 | Samsung | Observation 1: For uni-directional RRH deployment in Scenario-B, with single beam per RRH utilized, there is around 20dB margin compared against PC4 REFSENS requirement, which is 10dB lower than Scenario-A. Observation 2: For uni-directional RRH deployment in Scenario-B, with 2 beams used per RRH panel, the cellular coverage over the region near to RRH site can be significantly enhanced, even for one fixed RX beam used in UE side. Observation 3: For uni-directional RRH deployment for Scenario-B, the smallest beam dwelling time can be in the range of [1.61, 2.29] seconds for UE maximum speed of 350kmph.Observation 4: For Scenario-B, if scheme-1 used for bi-directional RRH deployment, around 20-25dB margin above PC4 REFSENS for [Mg, Ng, M, N, P]=[1, 1, 4, 8, 2] and [1, 1, 8, 8, 2], but significant performance loss is observed for narrower beam option, i.e., [Mg, Ng, M, N, P]=[1, 1, 8, 16, 2].Observation 5: For Scenario-B, if scheme-1 bi-directional RRH deployment is used， For RRH panel configuration [Mg, Ng, M, N, P]=[1, 1, 8, 16, 2], only single beam per RRH panel can’t provide satisfactory coverage.Observation 6: For Scenario-B, if scheme-1 used for bi-directional RRH deployment, two beams per RRH panel can provide satisfactory coverage.Observation 7: For bi-directional RRH deployment in Scenario-B, the scheme-2 (connecting to nearest RRH except coverage hole) is not recommended to be used. Observation 8: For bi-directional RRH deployment for Scenario-B, the beam dwelling time can be in the range of [1.68, 1.92] seconds for UE maximum speed of 350kmph. |
| R4-2106694 | Nokia, Nokia Shanghai Bell | Proposal 1: RAN4 to clarify based on the operators’ input if regular (i.e., low-speed non-HST) UEs can be connected to the same cell together with a HST CPE moving at maximum speed.Observation 1: In LoS conditions, without interference, the coverage area (over the railway track) of one RRH with one beam per panel is more than several Ds. Hence, even one beam per RRH can provide sufficient coverage.Observation 2: The usage of the beams pointed more perpendicular to the railway track is very limited. Out of a maximum of four beams per RRH, only two are reasonably used based on our simulation results. Even though one beam can provide sufficient coverage, we do not see a need to limit the number of beams per RRH only to one since the deployment with two beams is more general.Proposal 2: RAN4 to use 1 or 2 beams per RRH panel in uni-directional deployments for Scenario B.Proposal 3: RAN4 to use only 1 beam (TCI state) per RRH panel in uni-directional deployment with Full SFN transmission scheme for Scenario B.Proposal 4: RAN 4 not to use PDSCH combining in HST FR2 bi-directional deployment, Scenario B.Proposal 5: RAN4 to decide if more than two beams per RRH are beneficial in bi-directional deployment, scenario B.Observation 3: The utilization of only one panel pointing to upside is less efficient in HST FR2 Scenario B than two panels per CPE oriented into opposite directions. However, we have not observed any mobility problem in this setting either, even though in our analysis, only one beam cooriented with the panel boresight was used.Proposal 6: RAN4 to decide if further analysis is needed regarding one panel per CPE pointing to upside and having analog beams directed to forward and backward in HST FR2 Scenario B. |
| R4-2106827 | Huawei, HiSilicon | Observation 1: There is no any coverage issue under HST FR2 Scenario B assuming PC4 for both uplink and downlink.Proposal 1: Use 2 beams for Bi-directional deployment for Scenario B (700m/150m).Proposal 2: Use one beam for Uni-directional deployment for Scenario B. |
| R4-2104677 | Ericsson | Observation 1: The capacity for FR2 HST can be doubled by operating uni-directional connections in both directions.Observation 2: Attempting to operate with more than one UE / serving BS per direction may lead to significant inter-cell interference, removing most of the capacity benefit.Observation 3: The capacity limit for FR2 HST appears to be around 1Gbps / 100MHz.Proposal 1: Consider 1 UE panel per direction when setting requirements |
| R4-2104925 | ZTE Corporation | Observation 1: If (pre-)compensation of Doppler shift is considered at CPE or network side the max supported speed can be increased under the same RS density and SCS configuration.Observation 2: If 2 or more CPE per train are introduced, it needs to be clarified whether CPEs work jointly or independently.Proposal 1: To consider supporting handheld UE for HST\_FR2 with lower priority.Proposal 2: If complexity is the concern, one CPE per train can be prioritized for HST\_FR2. |

## Open issues summary

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

### Sub-topic 1-1 General Assumptions

*Sub-topic description:*

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

**Issue 1-1-1: UE antenna element parameters**

* Proposals
	+ Proposal 1 (Qualcomm): Set UE antenna parameters the same as RRH except N=8, M=4 in simulation assumptions
	+ Proposal 2 (Samsung): [Mg, Ng, M, N, P]=[1, 1, 4, 4, 2], 5dBi per element antenna gain
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-1-2: UE antenna panel(s) for forward and backward directions**

* Proposals
	+ Proposal 1 (Intel): RAN4 to consider CPE to be equipped with two panels pointed in opposite directions
	+ Proposal 2 (Nokia): RAN4 to decide if further analysis is needed regarding one panel per CPE pointing to upside and having analog beams directed to forward and backward in HST FR2 Scenario A.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-1-3: Number of CPE devices per train/carriage**

* Proposals
	+ Proposal 1 (Huawei, ZTE, Nokia, Intel, Ericsson): RAN4 requirement can be defined based on the baseline of 1 CPE device per train
	+ Observation 1 (Ericsson): Attempting to operate with more than one UE / serving BS per direction may lead to significant inter-cell interference, removing most of the capacity benefit.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-1-4: Necessity of JT in Scenario-A/B, Uni/Bi-directional RRH**

* Proposals
	+ Proposal 1 (Intel, Ericsson): RAN4 to focus only on DPS transmission mode for FR2 HST, don’t consider JT.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 1-2 Scenario-A, Uni-directional RRH

**Issue 1-2-1: Number of Beam for uni-directional RRH deployment, Scenario-A**

* For scenario-A, uni-directional, RRH parameter:
	+ Proposal 1 (Qualcomm, Samsung, Intel, Ericsson, Nokia): 1 beam per RRH panel
* For scenario-A, uni-directional, UE parameter:
	+ Proposal 1 (Ericsson, Samsung, Intel): 1 beam per UE panel (i.e., 1 beam per UE)
	+ Proposal 2 (QC): 1 beam per panel (two panels in opposite direction)
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-2-2: Uni-directional operation**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to modify NOTE2 on the number of RRHs per sight in uni-directional deployment as follows:
		- RAN4 focuses on 1 direction 1 train, but we are aware of the fact that either another panel to serve train towards the other direction is needed or a CPE is capable of Rx and Tx from the opposite direction. If this opposite direction is completely symmetric, the 1 direction study can apply directly.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-2-3: RRH boresight direction for uni-directional RRH deployment**

* Proposals
	+ Proposal 1 (Qualcomm): For the uni-directional model, the RRH boresight in azimuthal angle points to 780m from the projection of the RRH on the track.
	+ Proposal 2 (Huawei): Use boresight parallel to the railway for Uni-directional deployment for Scenario A.
	+ Proposal 3 (Samsung): RRH panel boresight pointed to the railway at the distance of Ds (projection of the neighboring RRH on the railway). Accordingly, for Scenario-A: Azimuth angle: 0.8 degree; Down-titling: 1.2 degree
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-2-4: Beam switching point**

* Proposals
	+ Proposal 1 (Samsung): Ds\_offset (illustrated in below figure) in the range of [40-81]m for Scenario-A uni-directional RRH deployment.

* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-2-5: Handover**

* Proposal (QC): For the uni-directional model, add an additional panel to the second and second last RRHs in a BBU to cover the HO region when Dmin is small. Define a network signaling to inform UE the presence of the additional panels.

T0

CID =1

CID =2

CID =2

HO

* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 1-3 Scenario-A, Bi-directional RRH

**Issue 1-3-1: Schemes for Bi-directional deployment**

* Proposals
	+ Proposal 1 (Samsung): To solve the issue of coverage hole for bi-directional deployment, there are two possible schemes:
		- Scheme-1: Connecting to 2nd-Nearest RRH;



* + - Scheme-2: Connecting to Nearest RRH except Coverage Hole.



* + Proposal 2 (Samsung): For Scenario-A, bi-directional RRH deployment:
		- If Scheme-1 for bi-directional deployment is adopted for Scenario-A, there is no benefit compared with uni-directional counterpart.
		- Scheme-2 for bi-directional deployment can be used for solve the coverage-hole issue, at the expense of 3 TX beam switching within each Ds.
	+ Proposal 3 (Nokia): RAN4 to discuss further if the connection quality in the area next to the RRH site in bi-directional deployment of Scenario A can be improved by switching to the reception from the neighboring RRH sites, e.g., using SFN or DPS schemes.
	+ Proposal 4 (Huawei): For Scenario-A, not consider bi-directional RRH deployment.
	+ Proposal 5 (QC): Use scheme 2 to resolve coverage issue in bi-directional channel
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-3-2: Number of Beam for bi-directional RRH deployment, Scenario-A**

* For scenario-A, bi-directional, RRH parameter:
	+ Proposal 1 (Nokia, Intel, Ericsson, QC): 1 beam per RRH panel, two panels in opposite directions
	+ Proposal 1a (Samsung): Depends on scheme-1 or 2
		- For scheme-1: 1 beam per RRH panel for Scheme-1
		- For scheme-2: one additional beam per RRH site needs to cover neighboring RRH site.
* For scenario-A, bi-directional, UE parameter:
	+ Proposal 3 (Samsung, Ericsson): 1 beam per UE panel (i.e., 2 beam per UE)
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-3-3: RRH boresight direction for bi-directional RRH deployment**

* Proposals
	+ Proposal 1 (Qualcomm): For the bi-directional model, the RRH boresight in azimuthal angle points to 780m from the projection of the RRH on the track.
	+ Proposal 2 (Samsung): Different for Scheme-1 and 2:
		- For Scheme-1: Option-2: RRH panel boresight pointed to the railway at the distance of Ds (projection of the neighboring RRH on the railway)
		- For Scheme-2: RRH panel boresight pointed to the railway in the middle point between 2 RRHs
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-3-4: Beam Dwelling time**

* For scenario-A, bi-directional:
	+ Proposal 1 (Samsung): For single beam per Panel, For bi-directional RRH deployment for Scenario-A, the beam dwelling time can be in the range of [0.80, 1.99] seconds for UE maximum speed of 350kmph.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.
	+ Companies are encouraged to further disucss beam dwelling time based their own HST deployment scenario study, and the discussion outcome will be served as the basis for RRM discussion, e.g., the dwelling time for each beam may have implication on the required time duration for some RRM operation.

### Sub-topic 1-4 Scenario-B, Uni-directional RRH

**Issue 1-4-1: Number of Beam for uni-directional RRH deployment, Scenario-B**

* For scenario-B, uni-directional, RRH parameter:
	+ Proposal 1 (Ericsson, Huawei, Samsung): 1 beam per RRH panel
	+ Proposal 2 (Nokia): 1 or 2 beams per RRH panel
	+ Proposal 2a (Nokia): RAN4 to use only 1 beam (TCI state) per RRH panel in uni-directional deployment with Full SFN transmission scheme for Scenario B.
	+ Proposal 3 (ZTE): 4 beams per RRH panel
	+ Proposal 4 (QC): 4 beams with uneven separation ([0 7.5 15 22.5 37.5] relative angle in degree to boresight direction) per RRH panel
	+ Proposal 5 (Intel): 2 beams per RRH panel
* For scenario-B, uni-directional, UE parameter:
	+ Proposal 1 (Ericsson, Samsung): 1 beam per UE panel (i.e., 1 beam per UE)
	+ Proposal 2 (QC) 7 beams with separation ([0 7.5 15 22.5 30 37.5 45] relative angle in degree to boresight direction) on one side, 13 UE beams if consider RRHs on two sides, per UE panel
	+ Proposal 3 (Intel): 2 beams per UE panel
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-4-2: Beam switching point**

* Proposals
	+ Proposal 1 (Samsung): Ds\_offset (illustrated in below figure) in the range of [370-457]m for Scenario-B uni-directional RRH deployment.



* + Proposal 2(QC): 4 switching point per Ds (4 beams in total)
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 1-5 Scenario-B, Bi-directional RRH

**Issue 1-5-1: Schemes for Bi-directional deployment**

* Proposals
	+ Proposal 2 (Samsung): For Scenario-B, bi-directional RRH deployment:
		- If Scheme-1 if scheme-1 used for bi-directional RRH deployment, two beams per RRH panel can provide satisfactory coverage.
		- The scheme-2 (connecting to nearest RRH except coverage hole) is not recommended to be used.
	+ Proposal 3 (QC): Use scheme 2 for bi-directional model to resolve coverage issue

* + Proposal 4 (Nokia): RAN4 not to use PDSCH combining in HST FR2 bi-directional deployment, Scenario B.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-5-2: Number of Beam for bi-directional RRH deployment, Scenario-B**

* For scenario-B, bi-directional, RRH parameter:
	+ Proposal 1 (Ericsson): 1 beam per RRH panel
	+ Proposal 2 (Huawei, Nokia, Intel): 2 beam per RRH panel
	+ Proposal 2a (Samsung): if scheme-1 (connecting to 2nd-nearest RRH) is used, 2 beam per RRH panel
	+ Proposal 3 (ZTE): 4 beams per RRH panel
	+ Proposal 4 (QC): 4 beams with uneven separation ([0 7.5 15 22.5 37.5] relative angle in degree to boresight direction) per RRH panel
	+ Proposal 5 (Nokia): RAN4 to decide if more than two beams per RRH are beneficial in bi-directional deployment, scenario B.
* For scenario-B, bi-directional, UE parameter:
	+ Proposal 1 (Ericsson, Samsung): 1 beam per UE panel (i.e., 1 beam per UE)
	+ Proposal 2 (QC) 7 beams with separation ([0 7.5 15 22.5 30 37.5 45] relative angle in degree to boresight direction) on one side, 13 UE beams if consider RRHs on two sides, per UE panel
	+ Proposal 3 (Nokia): RAN4 to decide if further analysis is needed regarding one panel per CPE pointing to upside and having analog beams directed to forward and backward in HST FR2 Scenario B.
	+ Proposal 4 (Intel): 2 beams per UE panel (i.e., 4 beams per UE)
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-5-3: Beam Dwelling time**

* For scenario-B, bi-directional:
	+ Proposal 1 (Samsung): For two beam per Panel, for bi-directional RRH deployment for Scenario-B, the beam dwelling time can be in the range of [1.68, 1.92] seconds for UE maximum speed of 350kmph.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.
	+ Companies are encouraged to further disucss beam dwelling time based their own HST deployment scenario study, and the discussion outcome will be served as the basis for RRM discussion, e.g., the dwelling time for each beam may have implication on the required time duration for some RRM operation.

### Sub-topic 1-6 Comparison between Uni-/Bi-directional RRH Deployment

*Sub-topic description*

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

**Issue 1-6-1: Comparison between uni- and bi-directional RRH deployment**

* Proposals
	+ Observation 1 (Ericsson): Bi-directional deployment is inferior to uni-directional deployment for scenario B.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.
	+ Companies are also welcomed to provide further views between bi-directional and uni-directional deployment.

### Sub-topic 1-7 Signaling

**Issue 1-7-1: Necessity of Signaling**

* Proposals
	+ Proposal 1 (Huawei): Do not introduce any signaling for Bi-directional deployment for HST FR2 in Rel-17.
	+ Proposal 2 (Nokia): If found to be needed, RAN4 to continue the discussion of issues related to the deployment type and UE capabilities signaling in the RRM track.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 1-8 Other Issues Identified in This Meeting

**Issue 1-8-1: Track curvature and impact on RRH separation**

* Proposals
	+ Observation 1 (Ericsson): For 350km/h scenarios, track curvature is not sharp and coverage can be provided with 1 TX/RX beam also for curves with 700m BS separation.
	+ Observation 2 (Ericsson): For 120km/h scenario, curves may in some cases be sharper. Coverage with 1TX/RX beam for such curves can be provided if BS are spaced around 400m around the curve. (Alternatively, multiple beams could be used).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-8-2: Consider 1 RRH site per BBU**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to consider also regular (non-SFN/non-DPS) deployment with 1 RRH site per BBU.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-8-3: High difference in propagation delays**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to elaborate further on which deployments and propagation schemes are exposed to the very different propagation delays. Then, quantitively evaluate the implications in these scenarios both from the demodulation and RRM perspectives.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-8-4: Dedicated network for roof-mounted CPE**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to assume that in HST FR2 Scenario A, only high-speed CPEs installed on the roof of the train can be present in the network.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-8-5: Handheld UE for FR2 HST**

* Proposals
	+ Proposal 1 (ZTE): To consider supporting handheld UE for HST\_FR2 with lower priority.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-8-6: The ability of Multi-beam RX or TX at UE**

* [Moderator]: It is noted that the following agreement is achieved in RAN4#98-e:

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| * Bi-directional operation for two panels (if any):
	+ Follow Rel-15/16 principle of “only one panel to TX/RX at a time”.
	+ FFS signaling is needed.
 |

* Proposals
	+ Proposal 1 (ZTE): The ability of multi-beam Rx or Tx at a time can be considered for CPE under uni-directional situation of scenario-A/B.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-8-7: Presence of regular UE in the network**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to clarify based on the operators’ input if regular (i.e., low-speed non-HST) UEs can be connected to the same cell together with a HST CPE moving at maximum speed.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

Sub topic 1-1

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| **Company** | **Comments** |
| Ericsson | **Issue 1-1-1: UE antenna element parameters**We assumed 4x4 UE array. Most likely the assumption does not make much difference to the conclusions on the reference scenario and requirements.**Issue 1-1-2: UE antenna panel(s) for forward and backward directions**We assume 2 panels pointing in opposite directions. In this scenario though it is more optimal to operate as 2 UEs, each operating uni-directional than bi-directional (double throughput obtained).We do not see any use for the upside pointing UE as it does not achieve full coverage.Support proposal 1.**Issue 1-1-4: Necessity of JT in Scenario-A/B, Uni/Bi-directional RRH**JT does not work efficiently in uni-directional as the two paths will be separated by a delay larger than the CP. For bi-directional, we do not see any advantages over uni-directional and it requires double panel operation for the same UE. It is better to transmit different data from opposite directions than the same signal (doubles capacity). Hence no need to consider JT. |
| ZTE | **Issue 1-1-1: UE antenna element parameters**4x4 or 2x4 UE array can be considered**Issue 1-1-2: UE antenna panel(s) for forward and backward directions**Support proposal 1**Issue 1-1-3: Number of CPE devices per train/carriage**1 CPE per train as baseline for RAN4 requirement**Issue 1-1-4: Necessity of JT in Scenario-A/B, Uni/Bi-directional RRH**JT(full SFN) is inferior to DPS. |
| Intel | **Issue 1-1-1: UE antenna element parameters**Prefer to keep both 4x4 and 2x4 options for UE antenna array**Issue 1-1-2: UE antenna panel(s) for forward and backward directions**Support proposal 1.@Ericsson: we agree that we can double throughput by serving 2 UEs in different directions, but it’s better to have them non-co-located to avoid interference (even though it is low due to antenna patterns filtering). Anyway, it doesn’t affect the requirements definition.**Issue 1-1-3: Number of CPE devices per train/carriage**Support proposal 1.**Issue 1-1-4: Necessity of JT in Scenario-A/B, Uni/Bi-directional RRH**Support proposal 1. We do not see any benefits in JT |
| Nokia, Nokia Shanghai Bell | **Issue 1-1-1: UE antenna element parameters**In our simulations, we used PC4 assumptions agreed in the WF of RAN4#97e meeting (R4-2017828) with a configuration [Mg, Ng, M, N, P] = [1, 1 or 2, 4, 4, 2], i.e., with 1 or 2 CPE panels. This parametrization includes Proposal 2. We propose to use it as a reference, e.g., in simulation parameters.However, we do not think that UE/CPE antenna panel configuration needs to be defined strictly as a part of deployment configuration.**Issue 1-1-2: UE antenna panel(s) for forward and backward directions**In our simulations, we have observed that CPE can be potentially equipped with only one antenna panel oriented upward. Such configuration results in the considerable loss in system performance due to the lower SINR in comparison to two-panel CPE. However, we have not observed mobility problems either even though the CPE beam configuration was not optimized. We studied only one beam co-oriented with the panel.**Issue 1-1-3: Number of CPE devices per train/carriage**In our simulations with multiple CPEs per train, briefly reported in R4-2106639 (Figure 5), we observed an increase in interference in comparison to only one CPE per train (no interference). As the signal stays on sufficient level there is no considerable impact on mobility performance. Just a few occasional failures were observed in bi-directional setting. Hence, we can build the RRM requirement based on 1 CPE per train.**Issue 1-1-4: Necessity of JT in Scenario-A/B, Uni/Bi-directional RRH**We do not see enough reasons to exclude JT/Full-SFN scheme for the analysis now. There is a number of issues that are still under discussion which will impact this decision. For example, one-panel CPEs can benefit from JT operation in bi-directional setting (Issues 1-1-2), JT can be more efficient in improving signal level next to the RRH (Issue 1-3-1).Additionally, the DPS scheme without the assumption of ToC or perfect timing offset knowledge can also face similar issues as JT in uni-directional deployments (Issue 1-8-3).  |

Sub topic 1-2

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| **Company** | **Comments** |
| XXX | **Issue 1-2-2: Uni-directional operation**Agree with the statement. Also, the “CPE” could be configured as 2 UEs both operating uni-directional but in different directions. Still from a requirements point of view it would look like single direction though.**Issue 1-2-3: RRH boresight direction for uni-directional RRH deployment**We assumed boresight parallel, but in our opinion any of these options works well.**Issue 1-2-4: Beam switching point**It is not critical exactly where the switching is as long as it is in the range 740-800m. The Samsung proposal is OK.**Issue 1-2-5: Handover** We do not see the need for the extra panel. Good coverage around a BS can be obtained from the previous BS and only 1 beam per BS. |
| ZTE | **Issue 1-2-1: Number of Beam for uni-directional RRH deployment, Scenario-A**For scenario-A,uni-directional 1 beam per RRH panel can be supportedSince candidate scheme of full SFN is not excluded, the number of beam for UE panel should not be restricted to 1, as multi-beam is helpful to deal with propagation difference.**Issue 1-2-2: Uni-directional operation**Agree**Issue 1-2-3: RRH boresight direction for uni-directional RRH deployment**Considering dmin of scenario-A, the 3 options are very close. The height of the RRH, the height of the antenna and the switching point should be considered to reflect a more realistic deployment.**Issue 1-2-4: Beam switching point**Agree the proposal |
| Intel | **Issue 1-2-1: Number of Beam for uni-directional RRH deployment, Scenario-A**Support one fixed beam per panel both on RRH and UE sides. We think that even in uni-directional deployment UE should be equipped with 2 panels. It should sweep over both panels at least when it enters the network to define the direction of uni-directional deployment. **Issue 1-2-2: Uni-directional operation**Ok with Proposal 1**Issue 1-2-3: RRH boresight direction for uni-directional RRH deployment**There is almost no difference between the proposals: 0.08° difference between P1 and P3 and 0.8° difference between P2 and P3. Prefer Proposal 3 as it is more straightforward.**Issue 1-2-4: Beam switching point**Ok with the proposal**Issue 1-2-5: Handover** Based on our analysis HO is not a problem for HST in FR2. However, we are ok to keep it for further study |
| Nokia, Nokia Shanghai Bell | **Issue 1-2-1: Number of Beam for uni-directional RRH deployment, Scenario-A**We agree with Proposal 1.**Issue 1-2-2: Uni-directional operation**From the previous version of the Note it followed that in uni-directional deployment it should always be two panels at RRH site pointed into opposite directions to support the trains moving in opposite directions (even though one of the mis used at a time). In our opinion, it is enough is also possible to have only one panel at RRH. Then, if the CPE has two panels, then one of those can be used depending on the train direction.**Issue 1-2-3: RRH boresight direction for uni-directional RRH deployment**We used Proposal 3 in our simulations because it was originally included in the WF at the RAN4#97-e. Further optimizations can be made if the problems in RRM performance are found. For the moment it is not the case. Hence, we preferer to keep Proposal 3 as a reference for simulations, but other options should not be precluded.**Issue 1-2-4: Beam switching point**In general, we agree that the beam switching will, probably, happen not exactly under the RRH site location but at some distance from it. However, the exact point of beam switching might depend on many factors including environmental (e.g. slow fading), implementational (the orientation of antenna panels and beam configuration, side lobes, etc.), reason of beam switch (e.g. HO-based or based on L1 measurements), etc. Therefore, in our opinion, beam switching point cannot be used as a deployment parameter.We do not see a need to target for an agreement in this issue. The discussion can continue in the propagation models topic, where Ds\_offset can be present as a parameter.**Issue 1-2-5: Handover** In the scenario under discussion, up to our best knowledge, that are no issues neither with the coverage nor with the signal strength. Interference between the SSB resources of neighbouring cells can be avoided by using TDM or FDM mechanisms available in the NR.In our simulations, we have not observed any issues with HO performance. Therefore, it is not very clear to us why additional panel is needed. |

Sub topic 1-3

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| **Company** | **Comments** |
| Ericsson | **Issue 1-3-1: Schemes for Bi-directional deployment**We generally do not see a use or need for bi-directional. Either scheme may be feasible, connecting to 2nd nearest is more useful. However it would be better to operate uni-directional in both directions than bi-directional (doubles capacity).**Issue 1-3-4: Beam Dwelling time** We should take care that the beam dwelling time for bi-directional is not the thing driving RRM requirements if the bi-directional deployment anyhow does not have gains above uni-directional. |
| ZTE | **Issue 1-3-1: Schemes for Bi-directional deployment** Scheme-2 is preferred for scenario-A**Issue 1-3-2: Number of Beam for bi-directional RRH deployment, Scenario-A**Proposal 1 is supported.For UE parameter, if 2 panels are assumed for CPE proposal 3 can be supported.**Issue 1-3-3: RRH boresight direction for bi-directional RRH deployment**Scheme 1 is supported  |
| Intel | **Issue 1-3-1: Schemes for Bi-directional deployment**Scheme-1 is less efficient than uni-directional deployment in terms of link budget.@Samsung: How does beam switch is assumed to be triggered in Scheme-1? Is it some location-based or measurement-based decision?Scheme-2 is preferred.We have similar observation as Ericsson. Uni-directional deployment seems to be more straightforward while it still has sufficient link budget. We think that it is more beneficial to use bi-directional deployment as two uni-directional deployments which can serve 2 UEs looking in different directions.**Issue 1-3-2: Number of Beam for bi-directional RRH deployment, Scenario-A**Support Proposal 1 and 3.For Proposal 1a, based on Samsung’s tdoc single beam should also work well for scheme-2.**Issue 1-3-3: RRH boresight direction for bi-directional RRH deployment**Ok with Proposal 2, Scheme-2**Issue 1-3-4: Beam Dwelling time** Ok with Proposal 1 |
| Nokia, Nokia Shanghai Bell | **Issue 1-3-1: Schemes for Bi-directional deployment**We do not see a need to consider two different schemes in this issue. Both schemes are possible if bi-directional deployment is considered, i.e. scheme two cannot be prohibited. The main reason why Scheme-2 might not be feasible is because the CPE does not have enough time to switch to the beams of the neighbouring RRHs. For example, if neighbouring RRHs belong to different cells, then CPE usually might not be able to HO to them in the area next to the RRH. However, if JT or DPS is used, CPE might be still able use the neighbouring RRHs. That what we are proposing to study further.**Issue 1-3-2: Number of Beam for bi-directional RRH deployment, Scenario-A**Regarding Proposal 1a, in our simulation results we observe that the area under the RRH site is in the coverage of the neighbouring RRHs. Moreover, there is hardly any space available for one more beam in this scenario. Hence, only one beam can be used in practice (Proposal 1).Regarding the number of CPE beams, it is necessary to clarify Issue 1-1-2 before.However, if two panels per CPE are used, then 1 beam per panel assumption is fine for us.**Issue 1-3-3: RRH boresight direction for bi-directional RRH deployment**We think that in Scenario A the proposed differences in the configuration of the beams have minor impact on minima performance requirements because the beams a almost parallel to the track.**Issue 1-3-4: Beam Dwelling time** In general, we agree that beam dwelling time is important statistics. However, the exact values may depend on many factors and implementation. The core of the proposal still left unclear to us.Regarding the observed values, in scenario A, bidirectional setting, in our simulations we see the median value of Time-of-Stay per cell on the level of 2 seconds. Note that slow fading model was used in our simulations and other parameters can be found in our RRM contribution (R4-2106583). |

Sub topic 2-4

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| **Company** | **Comments** |
| Ericsson | **Issue 1-4-1: Number of Beam for uni-directional RRH deployment, Scenario-B**We are OK to consider 1-3 RRH beams per panel for scenario B; although operation with 1 beam is feasible, for straight track the coverage can be improved slightly with 2-3 beams and also curves in the track may be better covered.For the UE, we are OK to consider 1-2 beams; 2 beams may enable further coverage optimization and robustness where there are curves.**Issue 1-4-2: Beam switching point**We are OK with proposal 1; this aligns with our observations. |
| ZTE | **Issue 1-4-1: Number of Beam for uni-directional RRH deployment, Scenario-B**3 or 4 beams can be considered for scenario-B uni-directional deployment.For UE parameter, 2 or more beams per panel.  |
| Intel | **Issue 1-4-1: Number of Beam for uni-directional RRH deployment, Scenario-B**Based on our analysis single beam per RRH panel is not enough to cover full inter-RRH distance. Symmetrically, single beam at UE is also not enough. Prefer to have 2 beams per panel both at UE and RRH sides**Issue 1-4-2: Beam switching point**Ok with Proposal 1. |
| Nokia, Nokia Shanghai Bell | **Issue 1-4-1: Number of Beam for uni-directional RRH deployment, Scenario-B**In non-JT schemes, the number of RRH beams per panel can be over two but as it is shown in our contribution (R4-2106694) the usage of the beams oriented perpendicular to the railways track is very limited. Hence, two beams per RRH panel looks to be a reasonable assumption for us.Regarding the number of UE beams, we have not observed any performance problem in simulations with only one beam per CPE. Thus, 1 or 2 beams per CPE panel is a reasonable choice.**Issue 1-4-2: Beam switching point**Similarly to our comment in Issue 1-2-4, we propose to continue the discussion together with propagation conditions in Topic 2, where Ds\_offset can be considered as model parameter. |

Sub topic 2-5

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| **Company** | **Comments** |
| Ericsson | **Issue 1-5-1: Schemes for Bi-directional deployment**We do not see any benefit from bi-directional operation. If we would do it, we agree with proposals 2 and 4. However a more efficient use of panels is to operate unidirectional in both directions and operate the CPE as if it is 2 UEs.**Issue 1-5-2: Number of Beam for bi-directional RRH deployment, Scenario-B**We are OK with 1-3 beams per RRH and 1-2 per UE.**Issue 1-5-3: Beam Dwelling time**We should take care that the bi-directional beam dwelling time does not drive RRM requirements if it is not clear that there is a benefit from bi-directional operation compared to uni-directional. |
| ZTE | **Issue 1-5-1: Schemes for Bi-directional deployment**Scheme 2 (Nearest RRH) is supported .**Issue 1-5-2: Number of Beam for bi-directional RRH deployment, Scenario-B**2 or more beams per RRH panel and 4 or more beam per CPE(2 or more beams per panel if 2 panels are assumed) |
| Intel | **Issue 1-5-1: Schemes for Bi-directional deployment**Same comment as for Scenario A. Uni-directional operation seems to be more beneficial in bi-directional deployment.In case of bi-directional operation, we support Proposal 3 (Scheme-2).**Issue 1-5-2: Number of Beam for bi-directional RRH deployment, Scenario-B**2 beams per RRH panel and 2 beams per UE panel should be enough for sufficient coverage**Issue 1-5-3: Beam Dwelling time**Ok with the proposed values. Agree with Ericsson’s comment: these values should not be used in RRM requirements definition until the benefits of bi-directional operation will be clarified. |
| Nokia, Nokia Shanghai Bell | **Issue 1-5-1: Schemes for Bi-directional deployment**We have a similar comment as for the Issue 1-3-1. There is no difference in the described schemes 1 and 2. It is just a matter of CPE to be able to switch/HO to the neighbouring RRHs.**Issue 1-5-2: Number of Beam for bi-directional RRH deployment, Scenario-B**Based on our simulations, if the number of beams is over two, the beams that are more perpendicular to the railway track are used much less frequently then the two beams that are more parallel to the track. Hence, two beams per RRH panel looks to us as a reasonable choice in scenario B.On the CPE side, one beam per CPE panel should be sufficient, but two beams per RRH can be considered as well.**Issue 1-5-3: Beam Dwelling time**Similar comment as for the Issue 1-3-4.For reference, based on our simulations, the median beam dwelling time in the scenario B with two beams per RRH panel was around 0.8 second. |

Sub topic 2-6

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| **Company** | **Comments** |
| Ericsson | Note we have the same observation for scenario A. It is not obvious why to use bi-directional. With 2 panels in each direction at the UE and RRHs, the system could be operated as uni-directional in each direction with the CPE acting as 2 UEs. This would double the capacity compared to operating as bi-directional. |
| ZTE | **Issue 1-6-1: Comparison between uni- and bi-directional RRH deployment**The bi-directional means that the RRH is mounted with 2 panels. We think bi-directional deployment can improve coverage or capacity. Or maybe the bi-directional deployment should be clarified. |
| Intel | **Issue 1-6-1: Comparison between uni- and bi-directional RRH deployment**As commented before, we find it more beneficial to use bi-directional deployment for uni-directional operation. |
|  | **Issue 1-6-1: Comparison between uni- and bi-directional RRH deployment**In our opinion, the requirements should be designed taking both possible deployments into account.  |

Sub topic 1-7

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| **Company** | **Comments** |
| Ericsson |  **Issue 1-7-1: Necessity of Signaling**This can be discussed in RRM if decided that bi-directional should be included. |
| Intel | **Issue 1-7-1: Necessity of Signaling**Need to agree first, whether bi-directional operation should be considered.  |

Sub topic 1-8

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| **Company** | **Comments** |
| Ericsson | **Issue 1-8-2: Consider 1 RRH site per BBU**This can be considered in addition to DPS; not clear does it make any difference to the requirements though. **Issue 1-8-3: High difference in propagation delays**There is a need for uni-directional for a mechanism to re-set the UL TA when the serving BS is changed; this needs to be further considered (but a solution should be possible).**Issue 1-8-4: Dedicated network for roof-mounted CPE**Makes sense; there will not be other types of UE directly along the track as in scenario A.**Issue 1-8-5: Handheld UE for FR2 HST**Wall losses would prevent such UEs from connecting. Also, the orientation of the UEs would be random. Scenarios and RRM requirements could be very different. The WID states that the focus should be on roof mounted UEs. We prefer to exclude handheld UEs and keep the focus on roof mounted UE.**Issue 1-8-6: The ability of Multi-beam RX or TX at UE**We do not see a need for multi-beam UE. However, operating each panel of the UE as a separate UE with uni-directional transmission would double the capacity. |
| ZTE | **Issue 1-8-2: Consider 1 RRH site per BBU**Can be considered if only HST CPE is supported for HST\_FR2.**Issue 1-8-3: High difference in propagation delays**Agree |
| Intel | **Issue 1-8-2: Consider 1 RRH site per BBU**Agree that such deployment can be taken into account. But it should not be considered as a baseline**Issue 1-8-3: High difference in propagation delays**Agree with Proposal 1**Issue 1-8-4: Dedicated network for roof-mounted CPE**Other FR2 UEs can be present inside of the train. Even though we don’t expect to consider them in requirements definition, we should take them into account while defining Network signalling.**Issue 1-8-5: Handheld UE for FR2 HST**Requirements definition should be focused on roof-mounted CPE device.**Issue 1-8-6: The ability of Multi-beam RX or TX at UE**Based on WID multi-beam RX or TX is out of scope.**Issue 1-8-7: Presence of regular UE in the network**We assume that non-HST UEs can also be present in HST network. The railway is not always in rural environment. It is questionable to deploy RRHs (and gNB) every 700 meter along the whole railway for serving only very limited number of UEs a day without an option to reuse it for non-HST UEs |
| Nokia, Nokia Shanghai Bell | **Issue 1-8-1: Track curvature and impact on RRH separation**We agree with observation 1. However, in our opinion, 120 kmp/h scenario mentioned in Observation 2 is not HST scenario defined by the WID. Hence, it should not be considered further.**Issue 1-8-3: High difference in propagation delays**Both Full-SFN and DPS schemes without the assumption of ToC or perfect timing offset knowledge can also be challenging in uni-directional deployments.**Issue 1-8-5: Handheld UE for FR2 HST**According to the WID, we need to be “focused on train roof-mounted high-power devices”. We need to be realistic about the scope of the work in the WI and focus primarily on CPEs.**Issue 1-8-6: The ability of Multi-beam RX or TX at UE**The proposal needs further clarification. Is it related to the support of multiple active TCI states? If it is the case, it is necessary to verify if such joint transmission scheme is Rel-16 compatible. |

### CRs/TPs comments collection

*For close-to-finalize WIs and maintenance work, comments collections can be arranged for TPs and CRs. For ongoing WIs, suggest to focus on open issues discussion on 1st round.*

N/A because no CRs/TPs submitted under Topic-1.

## 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.*

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|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

### 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.*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

# Topic #2: Channel Modeling

*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** |
| R4-2104678 | Ericsson | Proposal 1: Adopt RMa pathloss model for scenario 2.Proposal 2: Adopt the single tap fading model for scenario 2. |
| R4-2105025 | Samsung | Proposal-1: If there is no further evidence from measurement campaign, RAN4 choose TS38.901 RMa LoS pathloss model used for link budget evaluation for Scenario-B. Proposal-2: The single-tap can be assumed for a single TX-RX link for Scenario-B. Observation-1: As a candiate channel profile for bi-directional RRH deployment sceanrio, the single tap channel profile is obtained by applying the parameters of Scenario-A and B into the profile in TS38.101-4 B.3.1. Observation-2: For HST-DPS for uni-directional RRH deployment, the Doppler shift trajectory is dependent on the switching point configured between two RRHs. Proposal-3: The switching point between two RRHs are assumed as the Table 1.Table 1. Switching point between two RRHs (Ds\_offset is defined as below Figure 2/4)

|  |  |  |
| --- | --- | --- |
|  | UE moving towards serving beam | UE moving away from serving beam |
| Scenairo-A (Ds = 700m , Dmin = 10m) | Ds\_offset = 700 + 40 (meter) | Ds\_offset = 40 (meter) |
| Scenario-B (Ds = 700m , Dmin = 150m) | Ds\_offset = 700 + 370 (meter) | Ds\_offset = 370 (meter) |

Proposal-4: For HST-DPS channel for uni-directional RRH deployment (Alt-1, UE moving towards serving beam), the cosine of angle used in Doppler shift is provided as below: (eq. 1) (eq. 2) (eq. 3)Observation-3: Doppler shift trajectory is demonstrated in Fig.3 for HST-DPS Alt-1: UE Moving towards Serving Beam.Proposal-5: For HST-DPS channel for uni-directional RRH deployment (Alt-2, UE moving away from serving beam), the cosine of angle used in Doppler shift is provided as below: (eq. 4) (eq. 5) (eq. 6)Observation-4: Doppler shift trajectory is demonstrated in Fig.4 for HST-DPS Alt-2: UE Moving Away from Serving Beam.Observation-5: For HST-DPS for bi-directional RRH deployment, the Doppler shift trajectory is dependent on the beam management scheme to be concluded from deployment scenario study.Proposal-6: For HST-DPS channel for HST-DPS for bi-directional deployment, the cosine of angle used in Doppler shift is provided as below: (eq. 7) (eq. 8) (eq. 9)Observation-6: If we assume UE is served by 2nd-nearest RRH, Doppler shift trajectory is demonstrated in Fig.6 for FR2 HST bi-directional RRH deployment.Proposal 7: Channel models for uplink and downlink performance evaluation are proposed as follows:Table 2. Proposed Channel Model Selection for UL and DL Performance Evaluation

|  |  |  |
| --- | --- | --- |
| Scenario (applicable to both A&B) | Uplink | Downlink |
| Bi-directional RRH Deployment | Single Tap Channel for FR2 HST | HST-DPS Channel for FR2 HST Bi-Directional RRH Deployment |
| Uni-directional RRH Deployment | HST-DPS Channel for FR2 HST Uni-Directional RRH Deployment: Alt-1: UE Moving towards Serving Beam |

 |
| R4-2106828 | Huawei, HiSilicon | Proposal 1: Use RMa Los pathloss model for Scenario B.Proposal 2: Use DPS channel model for both Uni-directional/Bi-directional and not consider SFN JT channel model for performance requirements. |
| R4-2106911 | Nokia, Nokia Shanghai Bell | On the Sceanio-B channel mode for link budget evaluation:Observation 1: LoS conditions can be assumed in the areas where the train is allowed to move at the maximum speeds that are evaluated in the WI.Proposal 1: RAN4 to choose TS38.901 RMa LoS pathloss model also for the evaluation of Scenario-B.On channel models for performance requirements in UL:Observation 2: Only single TX-RX link is used for UL transmission from CPE. This link is LoS and, hence, has only one strongly dominating path.Proposal 2: RAN4 to consider only single-tap propagation model for BS performance requirements, both in Scenario-A and Scenario-B.Observation 3: Doppler shift trajectories proposed for Single-tap high-speed train channel conditions in FR1 describe bi-directional setting. Historically, the model maintains the continuity of the frequency offset and avoids the alternation of Doppler shift sign when handing over from one RRH to another. However, we see it more realistic to have the alternation of the Doppler shift sing at RRH site change. This also makes sense for comparability between uni-direction and bi-directional channel models.Proposal 3: RAN4 to modify the single-tap propagation channel model for HST FR2 in UL to take into account the Doppler shift sign alternation in bi-directional setting when CPE is handing over from one RRH site to another.Observation 4: In uni-directional HST FR2 setting, the signal is always coming to the CPE from one direction. Doppler shift does not change the sign when CPE switches from one RRH to another. Hence, a different single-tap prorogation conditions should be considered in uni-directional setting.Below, we adapt the single-tap high-speed train channel conditions for uni-directional setting. The cosine of angle is given by:, , , ,where the initial distance of the train from RRH site over the railways track is , and is the distance between RRH sites, is RRH site - railway track distance, both in meters; is the velocity of the train in m/s, is time in seconds.Proposal 4: RAN4 to use single-tap propagation channel, as described above, in HST FR2 uni-directional setting for UL.On channel models for performance requirements in DL:Observation 5: A single-tap, SFN, and DPS propagation models were introduced in HST FR1 for DL.FR1 SFN channel profile cannot be re-used directly in FR2 because omni-directional transmission and reception cannot be assumed.In general, a larger variety of channel profiles can be considered in HST FR2: uni-directional JT, bi-directional JT, uni-directional DPS, uni-directional DPS.Proposal 5: RAN4 to decide which of the channel profiles (uni-directional JT, bi-directional JT, uni-directional DPS, uni-directional DPS) shall be considered for the CPE performance requirements.Proposal 6: Consider only two simultaneously received taps (i.e., only signals from two transmitting RRHs) in JT channel profile.Observation 6: DPS model in FR2 is nothing else than a single-tap channel profile with Doppler sign alternation at RRH site change.Proposal 7: RAN4 to modify the single-tap propagation channel model for HST FR2 in DL to take into account the Doppler shift sign alternation in bi-directional setting when CPE is handing over from one RRH site to another. Use this model in bi-directional DPS setting.Similarly to UL, we can adapt the single-tap high-speed train channel conditions for uni-directional setting. The cosine of angle is given by:, , , ,where the initial distance of the train from RRH site over the railways track is , and is the distance between RRH sites, is RRH site - railway track distance, both in meters; is the velocity of the train in m/s, is time in seconds.Proposal 8: RAN4 to use single-tap propagation channel, as described above, in HST FR2 uni-directional setting for DL. |
| R4-2106865(Moved from AI 8.7.5) | Ericsson | Proposal 1: RAN4 specify the unidirectional HST single tap channel model for UE/BS demodulation requirements for HST FR2 as follows: Where (Hz) is the maximum Doppler frequency, (m) is the distance between RRHs, (m) is the distance between RRH and railway track, (m/h) is the velocity of the train, and . Proposal 2: If RAN4 use the unidirectional HST single tap model, RAN4 should discuss further the parameters, i.e., , , , , and , according to the conclusion of the deployment scenario discussion.  |

## Open issues summary

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

### Sub-topic 2-1 Channel Model for Scenario-B Link Budget Analysis

*Sub-topic description:*

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

**Issue 2-1-1: Channel Model for Scenario-B Link Budget Analysis**

* Proposals
	+ Proposal 1 (Ericsson, Nokia, Samsung, Huawei): RAN4 to choose TS38.901 RMa LoS pathloss model also for the evaluation of Scenario-B.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-2 Fading model for a single TX-RX link in Scenario-B

*Sub-topic description:*

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

**Issue 2-2-1: One-Tap fading model for a single TX-RX link in Scenario-B**

* [Moderator] Issue 2-2-1 is related to Issue 2-1-1, and if LoS pathloss is adopted for Scenario, it is straightforward to use a one tap fading model to represent a single TX-RX link. This is the basis for the follow-up discussion on channel modelling for performance requirement, i.e., if one tap fading model is realistic enough to present a single TX-RX link in Scenario-B (same as Scenario-A), then the following model selection will make sense for performance requirement among (a) modified single-tap model, (b) modified HST-DPS model, (c) others.
* Proposals
	+ Proposal 1 (Ericsson, Samsung): The single-tap can be assumed for a single TX-RX link for Scenario-B.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-3 Uplink Channel Model for Performance Requirement

*Sub-topic description:*

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

**Issue 2-2-1: Channel model for BS performance requirements**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to consider only single-tap propagation model for BS performance requirements, both in Scenario-A and Scenario-B.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-3-1: Channel Model for Uplink Uni-directional RRH deployment**

* Proposals
	+ Proposal 1 (Nokia): Use single-tap propagation channel for UL uni-directional RRH deployment, as described below:

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,

, ,

* + Proposal 2 (Samsung, Ericsson (based on R4-2106865)): HST-DPS Channel for FR2 HST Uni-Directional RRH Deployment: Alt-1: UE Moving towards Serving Beam the cosine of angle θ(t) used in Doppler shift is provided as below

 (eq. 1)

 (eq. 2)

 (eq. 3)

|  |  |
| --- | --- |
|  | UE moving towards serving beam |
| Scenairo-A (Ds = 700m , Dmin = 10m) | Ds\_offset = 700 + 40 (meter) |
| Scenario-B (Ds = 700m , Dmin = 150m) | Ds\_offset = 700 + 370 (meter) |

* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-3-2: Channel model for Uplink Bi-directional RRH deployment**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to modify the single-tap propagation channel model for HST FR2 in UL to take into account the Doppler shift sign alternation in bi-directional setting when CPE is handing over from one RRH site to another.

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, .

|  |  |
| --- | --- |
| Parameter | Value |
| Scenario-A-260 | Scenario-A-350 | Scenario-B-260 | Scenario-B-350 |
|  | 700 m | 700 m | 700 m | 700 m |
|  | 10 m | 10 m | 150 m | 150 m |
|  | 260 km/h | 350 km/h | 260 km/h | 350 km/h |
|  | 14454 Hz | 19458 Hz | 14454 Hz | 19458 Hz |

* + Proposal 2 (Samsung): Reuse Single Tap Channel in TS38.104 for FR2 HST by updating parameters.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-4 Downlink Channel Model for Performance Requirement

*Sub-topic description:*

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

**Issue 2-4-1: Consider JT model for DL?**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to decide which of the channel profiles (uni-directional JT, bi-directional JT, uni-directional DPS, uni-directional DPS) shall be considered for the CPE performance requirements.
	+ Proposal 1a (Nokia): If JT adopted, consider only two simultaneously received taps (i.e., only signals from two transmitting RRHs) in JT channel profile.
	+ Proposal 2 (Huawei, Samsung): Use DPS channel model for both Uni-directional/Bi-directional and not consider SFN JT channel model for performance requirements.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-4-2: Channel model for Downlink Uni-directional RRH deployment**

* Proposals
	+ Proposal 1 (Nokia): Use single-tap propagation channel for DL uni-directional RRH deployment, as described below:

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|  |  |
| --- | --- |
| Parameter | Value |
| Scenario-A-260 | Scenario-A-350 | Scenario-B-260 | Scenario-B-350 |
|  | 700 m | 700 m | 700 m | 700 m |
|  | 10 m | 10 m | 150 m | 150 m |
|  | 260 km/h | 350 km/h | 260 km/h | 350 km/h |
|  | 7227 Hz | 9729 Hz | 7227 Hz | 9729 Hz |

* + Proposal 2 (Samsung, Ericsson (based on R4-2106865)): HST-DPS Channel for FR2 HST Uni-Directional RRH Deployment: Alt-1: UE Moving towards Serving Beam the cosine of angle θ(t) used in Doppler shift is provided as below

 (eq. 1)

 (eq. 2)

 (eq. 3)

|  |  |
| --- | --- |
|  | UE moving towards serving beam |
| Scenairo-A (Ds = 700m , Dmin = 10m) | Ds\_offset = 700 + 40 (meter) |
| Scenario-B (Ds = 700m , Dmin = 150m) | Ds\_offset = 700 + 370 (meter) |

* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-4-3: Channel model for Downlink Bi-directional RRH deployment**

* Proposals
	+ Proposal 1 (Nokia): RAN4 to modify the single-tap propagation channel model for HST FR2 in DL to take into account the Doppler shift sign alternation in bi-directional setting when CPE is handing over from one RRH site to another. Use this model in bi-directional DPS setting.
	+ , ,

, .

|  |  |
| --- | --- |
| Parameter | Value |
| Scenario-A-260 | Scenario-A-350 | Scenario-B-260 | Scenario-B-350 |
|  | 700 m | 700 m | 700 m | 700 m |
|  | 10 m | 10 m | 150 m | 150 m |
|  | 260 km/h | 350 km/h | 260 km/h | 350 km/h |
|  | 7227 Hz | 9729 Hz | 7227 Hz | 9729 Hz |

* + Proposal 2 (Samsung): HST-DPS Channel for FR2 HST Bi-Directional RRH Deployment. the cosine of angle used in Doppler shift is provided as below:

 (eq. 7)

 (eq. 8)

 (eq. 9)

* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

Sub topic 2-1

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | **Issue 2-1-1: Channel Model for Scenario-B Link Budget Analysis**Agree |
| Intel | Agree with proposal 1. |

Sub topic 2-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | **Issue 2-2-1: Channel model for BS performance requirements**We agree to proposal 1 |
| Intel | We support proposal that for both scenarios A and B propagation condition with single tap can be assumed. |
| Nokia, Nokia Shanghai Bell | **Issue 2-2-1: One-Tap fading model for a single TX-RX link in Scenario-B**In general, we agree with the proposal, however, we prefer to discuss needed the channel models in separate issues, e.g., as proposed in the Issues 2-2-1 for UL and Issues 2-4-1 in DL. |

Sub topic 2-3

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | **Issue 2-3-2: Channel model for Uplink Bi-directional RRH deployment**We should clarify whether bi-directional is really beneficial. If we do bi-directional requirements, either approach can work. |
| ZTE | **Issue 2-2-1: Channel model for BS performance requirements**Agree (issue index needs to be updated)**Issue 2-3-1: Channel Model for Uplink Uni-directional RRH deployment**Proposal 2 is preferred |
| Intel | **Issue 2-3-1: Channel model for BS performance requirements**Similar to issue 2-2-1 we support proposal 1.**Issue 2-3-2: Channel Model for Uplink Uni-directional RRH deployment**In order to agree on exact channel model, we need to discuss two main aspects:1. Should we assume continuous or non-continuous Doppler profile in UL direction?2. In which point we should assume UE switch operation from one RRH to another?Regardless of Tx scheme UE will instantly switch Tx frequency when switching from one RRH to another is performed. In this case we should also assume instant change of UL RX frequency. Therefore, non-continuous Doppler frequency profile should be assumed for UL channel model. Both proposal 1 and 2 if we properly understood them, suggest considering non-continuous Doppler frequency profile (HST DPS like channel model). The difference between these two options is starting point and switching point. We suggest further discuss whether some switching point offset should be introduced to the actual channel model profile or not,**Issue 2-3-3: Channel model for Uplink Bi-directional RRH deployment**Support proposal 1. It should be non-continuous Doppler frequency profile due to UE switching from one RRH to another. |
| Nokia, Nokia Shanghai Bell | **Issue 2-3-1: Channel Model for Uplink Uni-directional RRH deployment**We think that the model from Proposal 2 makes sense as well. It is necessary to analyse further the proposed values of Ds\_offset and if the difference to the case when UE is moving against serving beams. |

Sub topic 2-4

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | **Issue 2-4-1: Consider JT model for DL?**Proposal 2. JT is not feasible for unidirectional due to the time difference between the paths and not beneficial (and requiring two panel operation at the same UE) for bi-directional. |
| ZTE | **Issue 2-4-1: Consider JT model for DL?**JT(full SFN) is faced with propagation delay difference and doppler shift hopping so DPS is prioritized. |
| Intel | **Issue 2-4-1: Consider JT model for DL?**We support Proposal 2 because we do not see any value to configure JT scheme in HST FR2 deployments. We also should discuss which scenarios should be adopted for requriements definition: unidirectional or bidirectional. We do not see big difference between them from performance verification. Slightly prefer unidirectional scenario.**Issue 2-4-2: Channel model for Downlink Uni-directional RRH deployment**Regardless of Tx scheme Doppler frequency profile will be non-continuous in DL. In this case both proposals are aligned. Same time proposal 2 suggest considering some practical switching point. We can go with proposal 2 and further discuss exact offset value. It can be 0 if we agree that there is no need to consider it at all for performance verification.**Issue 2-4-3: Channel model for Downlink Bi-directional RRH deployment**Actual Doppler frequency profile depends on beam management assumptions and both proposals are valid but correspond to different beam management approaches. We suggest discuss this issue after outcome of deployment study. |
| Nokia, Nokia Shanghai Bell | **Issue 2-4-1: Consider JT model for DL?**This discussion should be based on the conclusions of HST FR2 Deployment in Topic 1. If JT scheme is agreed to be relevant to HST FR2, we do not see reasons to exclude corresponding model from pefromance requirements.**Issue 2-4-2: Channel model for Downlink Uni-directional RRH deployment**Similar comment as in Issue 2-3-1.**Issue 2-4-3: Channel model for Downlink Bi-directional RRH deployment**The difference in the equations between Proposal 1 and Proposal 2 might be just due to the different starting point of the Doppler trajectory. In our proposal, the CPE starts at point Ds/2 that is also used in the HST FR1 single-tap propagation model. |

### CRs/TPs comments collection

*For close-to-finalize WIs and maintenance work, comments collections can be arranged for TPs and CRs. For ongoing WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2105025(TP to TR 38.854) | Company A |
| Company B |
|  |

## 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.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

### CRs/TPs

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

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Topic #3: Demodulation Requirement

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2105028 | Samsung | Theoretical analysis for maximum supported velocity with different RS configuration Observation 1: It’s feasible to support up to 350km/h with 120kHz TRS configured for frequency offset tracking from DL perspective. Observation 2: It is not feasible to support maximum 350km/h velocity with targeting 30GHz carrier frequency under only DMRS configuration for UL .  Observation 3: It’s feasible to support up to 350km/h with combined DMRS + PTRS (120kHz) used for frequency offset tacking for UL. Then we bring evaluation results for both uplink and downlink with different channel modelling/deployment scenarios. UL performance evaluation Observation 4: Similar performance can be achieved for both bi-directional and un-directional deployment scenario. Observation 5: With 1 DMRS+PTRS (L=1, K=2) configuration, better performance can be achieved in terms of maximum throughput. Observation 6: With only DMRS (1+1+1) configuration, the achievable throughput is very lower, it is not feasible to support 350km/h @ 30GHz carrier frequency. Observation 7: From UL demodulation perspective, it is feasible to support the maximum speed with 350km/h, even with high carrier frequency up to 30GHz with PTRS configured.DL demodulation –Single Tap Observation 8: For rank1 transmission, it is feasible to support UE speed up to 350km/h with single tap channel Observation 9: For rank1 transmission with 260km/h, the maximum throughput for MCS 17 and MCS19 can be achieved around 10 dB SNR.  Observation 10: For rank1 transmission with 350km/h, the maximum throughput for MCS 13 can be achieved around 4 dB SNR. The maximum throughput for MCS 17 can be achieved around 12 dB SNR.DL demodulation - Uni-direction RRH deployment with DPS scheme Observation 11: Similar performance can be archived for scenario A (Dmin=10) and scenario B (Dmin=150) in uni-directional scenario with DPS transmission scheme.  Observation 12: For rank1 transmission, it is feasible to support UE speed up to 350km/h in uni-directional scenario with DPS transmission scheme Observation 13: For rank1 transmission with 260km/h UE speed, the maximum throughput for MCS 17 can be achieved round 10 dB SNR Observation 14: For rank2 transmission with 260km/h UE speed, the maximum throughput of MCS 17 can be achieved around 15 dB Observation 15: For rank1 transmission with 350km/h UE speed, the maximum throughput for MCS 17 can be achieved around 18 dB Observation 16: For rank2 transmission with 350km/h UE speed, the maximum throughput for MCS 17 cannot be achieved, the SNR of 70% maximum throughput is about 12 dB , the maximum throughput of MCS13 can be achieved around 12 dBDL demodulation- Bi-direction RRH deployment with DPS scheme Observation 17: Similar performance can be archived for scenario A (Dmin=10) and scenario B (Dmin=150) in bi-directional scenario with DPS transmission scheme.  Observation 18: For rank1 transmission, it is feasible to support UE speed up to 350km/h in bi-directional scenario with DPS transmission scheme Observation 19: For rank1 transmission with 260km/h UE speed, the maximum throughput for MCS 17 can be achieved round 10 dB SNR Observation 20: For rank2 transmission with 260km/h UE speed, the maximum throughput of MCS 17 can be achieved around 12 SNR Observation 21: For rank1 transmission with 350km/h UE speed, the maximum throughput for MCS 17 can be achieved around 19 dB SNR Observation 22: For rank2 transmission with 350km/h UE speed, the maximum throughput of MCS 17 cannot achieved, the SNR of 70% maximum throughput is about 12 dB, the maximum throughput of MCS 13 can be achieved around 12 dB SNRTo summary, based on our evaluation results and theoretical analysis over different deployment scenarios for DL and UL, the initial conclusion as following:Initial conclusion: It’s feasible to support UE velocity up to 350km/h under various deployment scenarios with 120kHz PTRS configured in uplink and 120kHz TRS configured in downlink. |
| R4-2106435 | Intel Corporation | Proposal #1: Assume the following reference signal(s) for DL frequency offset tracking:• For unidirectional deployment TRS, DMRS or TRS + PTRS• For bidirectional deployment TRS+ PTRSProposal #2: Assume the following reference signal(s) for UL frequency offset tracking: PTRS or DMRS + PTRS where PTRS density is not less than every second symbol.Proposal #3: Define different set of UL requirements to cover different frequency offset compensation implementation. |
| R4-2106473 | Qualcomm Incorporated | Observation 1: Current assumptions on the HST scenario, geometry of the deployment and UE movement with respect to the signal source might have implication on the design of the demodulation performance tests;Observation 2: Single probe OTA chambers, fixed beam and fixed UE position have been assumed to design FR2 radiated requirements;Proposal 1: RAN4 to discuss on the impact of the assumptions of a static UE and single probe OTA chambers on the FR2 high speed train demodulation test design;Proposal 2: For the definition of radiated demodulation requirements for FR2 HST, RAN4 should keep into account the testability of high power devices inside OTA chambers; |
| R4-2106829 | Huawei, HiSilicon | Observation 1: It is not feasible to support 350km/h without using PTRS for uplink.Observation 2: DMRS+PTRS can provide more accurate frequency offset estimation than PTRS for uplink.Proposal 1: To support 350km/h, RAN4 define performance requirements using TRS+SSB for tracking frequency offset for downlink.Proposal 2: To support 350km/h, RAN4 define performance requirements using DMRS+PTRS for tracking frequency offset for uplink. |
| R4-2106916 | Nokia, Nokia Shanghai Bell | On maximum supported speed in UL:Observation 1: In PUSCH with mapping Type B, allocation length 8 and 9 has the same DM-RS patterns. Since the performance of these two cases is very close. It would make more sense to introduce allocation length 10 instead of 9 to study sparser DM-RS pattern.Observation 2: Looking at PUSCH demodulation performance in single-tap propagation conditions, it can be concluded that:- 3 DM-RS (1+1+1) reference symbols are not sufficient to cope with frequency offset in all priority scenarios- 3 DM-RS (1+1+1) can be potentially used only with 260 kmph maximum train speed in uni-directional setting- The presence of PT-RS (time density 2) is needed to provide reliable connectivity at 350 kmph.Observation 3: PT-RS support is mandatory UE capability in FR2.Proposal 1: RAN4 to necessitate transmitting of PT-RS with PUSCH in HST FR2 deployments if it is decided to support 350kmph maximum train speed.Proposal 2: If RAN4 decides to use PT-RS signals in UL, then their time density should be 2.Proposal 3: If RAN4 to discuss whether 260 kmph speed can be supported without PT-RS, and what reference signals configuration can be used in this case.On maximum supported speed in DL:Observation 4: PT-RS were not introduced neither in Option 2 (DMRS (1+1+1)) nor in the PDSCH demodulation parameters. However, their usage is highly recommended in FR2. They are always present in UE FR2 PDSCH test configurations defined in TS 38.101-04.Observation 5: PDSCH transmission at 350 km/h speed can be supported in HST FR2 in single-tap propagation conditions if 3 DM-RS (1+1+1) and PT-RS (frequency density 1, time density 2) are used.Proposal 4: RAN4 to necessitate transmitting of PT-RS with PDSCH in HST FR2 deployments.Proposal 5: RAN4 to use PT-RS signals with time density 2 in DL. |
| R4-2105029 | Samsung | Proposal 1: No PDSCH requirement with HST single tap channel model in FR2Proposal 2: if needed to define PDSCH requirement with both RRH deployment scenarios, applicability rule can be further discuss to reduce the test effortsProposal 3: No PDSCH requirement for JT-SFN transmission scheme in bi-directional scenario. FFS on PDSCH requirement for JT-SFN transmission scheme in unidirectional scenarioProposal 4: DPS scheme 1a and 1b can be considered for PDSCH requirement in unidirectional scenario.Proposal 5: Only DPS scheme 1a can be considered for PDSCH requirement in bi-directional scenarioProposal 6: For 120 KHz, it is feasible to use the maximum Doppler frequency as 9722Hz for PDSCH requirement. |
| R4-2106436 | Intel Corporation | Proposal #1: Define DL demodulation performance requirements only with 120 kHz SCS and 100 MHz CBW.Proposal #2: Define DL demodulation performance requirements with 350 km/h UE speed.Proposal #3: Define DL demodulation performance requirements only with one deployment scenario (A or B).Proposal #4: Analyse impact of UE frequency error on DL demodulation performance and after that conclude on necessity of explicit modelling of UE frequency error during the test procedure.Proposal #5: Define DL demodulation performance requirements only with DPS Tx scheme.Proposal #6: Do not define PDCCH demodulation performance requirements for HST FR2. |
| R4-2106830 | Huawei, HiSilicon | 1. Define PDSCH performance requirements for HST FR2 with the following parameters:

|  |  |
| --- | --- |
| Parameter | Value |
| Maximum Doppler | 9596Hz |
| Channel model | single-tap, DPS |
| CBW/SCS | 100MHz/120kHz |
| PUSCH mapping | Type A, start symbol 1, duration 13 |
| DMRS | 1+1+1 |
| PTRS | KPTRS=2, LPTRS=1 |
| Antenna configuration | 2x2 |
| MCS | 17 |
| Test metric | 70% of maximum throughput |

 |
| R4-2106866 | Ericsson | Proposal 1: Assume UE uses TRS (4 symbol interval) for frequency offset tracking.Observation 1: Maximum Doppler frequency based on TRS is 14,000Hz if we don’t assume frequency error.Observation 2: Maximum Doppler frequency based on TRS is 11,000Hz if we assume frequency error of 0.1ppm at 30GHz. Observation 3: Considering the maximum throughput achievement, the maximum Doppler shift can be set up to about 12,000Hz for FR2 with SCS=120kHz if we configure DMRS 1+1+1 with the assumption UE does not perform frequency offset compensation. Observation 4: Considering the maximum throughput achievement, the maximum Doppler shift can be set up to about 12,000Hz for FR2 with SCS=120kHz even if we configure no additional DMRS symbols with the assumption UE performs frequency offset compensation. Proposal 2: Assume DMRS configuration with 1+1+1 for UE demodulation requirements. Proposal 3: Assume also DMRS configuration without additional DMRS symbols for single tap scenario. Proposal 4: Set the maximum Doppler shift for PDSCH demodulation requirements for HST FR2 by assuming the UE speed of 350km/h at the carrier frequency of 30GHz.Observation 5: Reception difference between two RRHs exceeds the CP with SCS=120kHz for both Scenarios A and B in the case of HST-SFN joint transmission. Proposal 5: For FR2 HST UE demodulation requirements, RAN4 should define the PDSCH demodulation requirements with the assumption UE receives PDSCH only from one RRH, e.g., HST single tap, multi-path fading (TDL), or HST-DPS, with the assumption of single FFT receiver. Proposal 6: RAN4 discuss whether to define PDSCH demodulation requirements for joint transmission assuming UE is capable of multiple FFT receiver. |
| R4-2104681 | Ericsson | Observation 1: Double-symbol DM-RS configuration is typically for MU-MIMO scenario and due to the presence of phase-noise, such configuration is generally not preferrable for FR2 BS.Observation 2: Taking frequency drift into consideration, under worst-case scenarios where Doppler reversal is expected, frequency offset estimation (FOE) based on PT-RS may be necessary for HST travelling faster than 250 km/h.Proposal 1: For single-tap channel model, PT-RS (with time density LPT-RS = 1) based FOE and (1+0) DM-RS symbol for channel estimation can be considered.Proposal 2: In case fading shall be considered, a low Doppler spread is most realistic (e.g. TDLA30-75). PT-RS (with time density LPT-RS = 1) based FOE and (1+0) DM-RS symbol for channel estimation can still be considered for low Doppler spread.Proposal 3: We think that the single tap channel model is sufficient and there is no real need to include TDLA30-75 (or any other fading channel) in addition.Proposal 4: If substantial fading would be expected for scenario B, more DM-RS would be required for channel estimation and DM-RS based FOE shall be considered. Potentially, a lower speed may need to be considered.Proposal 5: Check the PRACH demod performance with simulation with the following setup.- UE speed: same as PUSCH uses;- Carrier frequency: 28GHz and/or 30GHz;- Channel: AWGN, and/or TDL-A (if needed);- Format: A2, A3, B4, C2;- SCS: 120kHz;- Antenna: 1T2R;- Ncs: 0;- Test metric: missed detection rate = 1% while false alarm rate = 0.1%. |
| R4-2105030 | Samsung | PUSCH requirements:Proposal 1: Define PUSCH requirement with HST single tap channel model. Further discussion the test applicability rule of requirement for two RRH deployment scenario if needed.Proposal 2: Focus on the PUSCH requirement with open space scenario firstlyProposal 3: For 120 KHz SCS, it is feasible to use the maximum Doppler frequency as 19444Hz for PUSCH requirement.Proposal 4: The following simulation assumption for PUSCH requirement with HST single tap setup can be considered as * Waveform: CP-OFDM
* SCS&BW: 120 KHz SCS, 100 MHz
* RS Configuration: 1 DMRS symbol+ PTRS (L=1, K=2)
* Resource mapping type: type B
* Length of data symbol: 9
* MCS: 16
* Antenna configuration: 1Tx 2Rx low

Observation 1: PUSCH requirement with UL timing adjustment can be considered.PRACH requirements:Observation 2: No limitation for PRACH to support 350km/h velocity with carrier frequency 30GHz Proposal 5: For PRACH with short sequence format, only define the performance requirement for format C2 in Rel-17 FR2 HST WI. Proposal 6: Set frequency offset as 19444Hz for PRACH format requirement to align the Doppler shift assumption of PUSCHProposal 7: Reuse the following test parameters for PRAH format requirement

|  |  |  |
| --- | --- | --- |
| PRACH  | PRACH SCS  | Time error tolerance |
| preamble | (kHz) | AWGN |
| C2 | 120 | 0.26us |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PRACH preamble  | SCS (kHz) | Ncs | Logical sequence index | v |
| C2 | 120 | 69 | 0 | 0 |

PUCCH requirementsProposal 8: No PUCCH requirement for HST scenario  |
| R4-2106437 | Intel Corporation | Proposal #1: Define UL demodulation performance requirements only with 120 kHz SCS and consider 50, 100 and 200 MHz CBW.Proposal #2: Define DL demodulation performance requirements only with one deployment scenario (A or B).Proposal #3: Define UL demodulation performance requirements only with transform precoding disabled.Proposal #4: Define two different sets of UL demodulation performance requirements to distinguish two different possible frequency offset compensation approaches.Proposal #5: Assume PTRS or PTRS+DMRS based frequency offset tracking for UL demodulation performance requirements definition. PTRS density should not be less than every second symbol.Proposal #6: Do not define PUCCH demodulation performance requirements for HST FR2.Proposal #7: Define PRACH demodulation performance requirements only with AWGN conditions with 9722 Hz frequency offset and consider PRACH configuration from Table 1Table 1. Proposed PRACH preambles and configuration.Burst format SCS (kHz) Ncs Logical sequence index vA2, B4, C2 120 69 0 0Proposal #8: Define UL TA demodulation performance requirements for HST FR2 with scenario Y. |
| R4-2106780 | Nokia, Nokia Shanghai Bell | Channels to testProposal 1: Follow NR\_HST specification changes as baseline; test PUSCH, PUSCH UL TA, and PRACH.PUSCHProposal 2: Only test CP-OFDM waveform.Proposal 3: Only have 2Rx requirements.Proposal 4: Limit MCS to 16QAM max.Proposal 5: Configure both DM-RS (1+1) and PT-RS (K=2, L=1) to allow for up to 350km/h in single tap models.Proposal 6: Align all remaining configurations with FR1 HST.PRACHProposal 7: Have requirements for A2, B4, and C2.Proposal 8: Limit channel model to AWGN with frequency offset decided by maximum observable doppler shift.Proposal 9: Align all remaining configurations with FR1 HST. |
| R4-2106831 | Huawei, HiSilicon | 1. Preamble format 0/1/2/3 cannot be used for HST FR2.
2. Preamble format A1/A2/A3/B1/B2/B3/B4/C0 cannot be used for HST FR2.
3. Define PUSCH performance requirements for HST FR2 with the following parameters:

|  |  |
| --- | --- |
| Parameter | Value |
| Maximum Doppler | 19191Hz |
| Channel model | single-tap |
| CBW/SCS | 200MHz/120kHz |
| PUSCH mapping | Type B, start symbol 0, duration 10 |
| DMRS | 1+1+1 |
| PTRS | KPTRS=2, LPTRS=1 |
| Waveform | CP-OFDM |
| Antenna configuration | 1x2 |
| MCS | 16 |
| Test metric | 70% of maximum throughput |

1. Use C2 for HST FR2 performance requirements definition under AWGN channel with 19191 Hz frequency offset.
2. Define UL TA requirements with the following parameters:

|  |  |
| --- | --- |
| Parameter | Value |
| Channel model | Stationary UE: AWGN, Moving UE: AWGN |
| UE speed | 350 km/h |
| CP length | Normal |
| A | 1.25 μs |
| Δω | 1.04 s-1 |
| MCS | 16 |
| CBW | 200MHz |
| PUSCH resource allocation | 0 to 65 RB for moving UE, 66 to 131 for stationary UE |
| SRS resource allocation | last symbol in slot #3 in radio frames, CSRS = 33, BSRS =0, for 132 RB |

 |

## Open issues summary

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

### Sub-topic 3-1 Maximum Speed Feasibility Study

*Sub-topic description:*

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

**Issue 3-1-1: Uplink maximum speed feasibility study and requested RS configuration**

* Proposals
	+ To support 350kmph maximum speed:
		- Observation 1 (Samsung, Nokia, Huawei): Not feasible for only DM-RS configuration without PT-RS
		- Observation 2 (Samsung, Nokia, Huawei, Intel): Feasible for combined DM-RS+ PT-RS (density no less than 2) used for frequency offset tracking.
			* Observation 2a (Samsung): With 1 DMRS+PTRS (L=1, K=2) configuration, better performance can be achieved in terms of maximum throughput.
			* Observation 2b (Nokia): With 1+1 DMRS+PTRS (L=1, K=2) configuration.
		- Observation 3 (Intel): Feasible for PT-RS or DM-RS + PT-RS (density no less than 2) for frequency tracking.
		- Observation 4 (Ericsson): Feasible for
			* For single-tap channel model, PT-RS (with time density LPT-RS = 1) based FOE and (1+0) DM-RS symbol for channel estimation
			* In case fading shall be considered, a low Doppler spread is most realistic (e.g. TDLA30-75). PT-RS (with time density LPT-RS = 1) based FOE and (1+0) DM-RS symbol for channel estimation can still be considered for low Doppler spread.
			* We think that the single tap channel model is sufficient and there is no real need to include TDLA30-75 (or any other fading channel) in addition.
			* If substantial fading would be expected for scenario B, more DM-RS would be required for channel estimation and DM-RS based FOE shall be considered. Potentially, a lower speed may need to be considered.
		- Observation 5 (ZTE): If (pre-)compensation of Doppler shift is considered at CPE or network side the max supported speed can be increased under the same RS density and SCS configuration.
	+ To support 260kmph maximum speed:
		- Observation 6 (Nokia): Feasible for only DM-RS configuration without PT-RS
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-1-2: Downlink maximum speed feasibility study and requested RS configuration**

* Proposals
	+ To support 350kmph maximum speed:
		- Observation 1 (Nokia): Feasible in single-tap propagation conditions if 3 DM-RS (1+1+1) and PT-RS (frequency density 1, time density 2) are used.
		- Proposal 1 (Nokia): RAN4 to necessitate transmitting of PT-RS with PDSCH in HST FR2 deployments.
		- Observation 2 (Huawei, Samsung, Ericsson): Feasible by using TRS+SSB for tracking frequency offset for downlink.
		- Observation 3 (Intel): Feasible by using:
			* TRS, DMRS or TRS + PTRS, for unidirectional deployment
			* TRS+ PTRS, for bidirectional deployment
		- Observation 4 (Ericsson):
			* TRS (4 symbol interval) for frequency offset tracking
			* DMRS configuration with 1+1+1 for UE demodulation requirements (with frequency offset compensation before the demodulation process).
			* DMRS configuration without additional DMRS symbols for single tap scenario (without frequency offset compensation before the demodulation process).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-1-3: Carrier frequency for Doppler frequency calculation**

* Proposals
	+ Proposal 1: 28 GHz
	+ Proposal 2: 29.5 GHz
	+ Proposal 3: 30 GHz
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 3-2 UE Demodulation Requirement

*Sub-topic description*

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

**Issue 3-2-1: General test scope for UE demodulation requirements**

* Proposals
	+ Proposal 1 (Samsung, Intel, Huawei, E///, Nokia):
		- Introduce PDSCH requirement
	+ Proposal 2 (Intel):
		- Do not define PDCCH demodulation performance requirements for HST FR2.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-2-2: Applicability rule**

* Proposals of Applicability rule for uni- and bi-directional RRH deployment scenarios
	+ Proposal 1 (Samsung): if needed to define PDSCH requirement with both RRH deployment scenarios, applicability rule can be further discussed.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-2-3: Requirement for Scenario A or B**

* Proposals
	+ Proposal 1 (Intel): Define DL demodulation performance requirements only with one deployment scenario (A or B).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-2-4: Transmission schemes for Scenario A or B**

* [Moderator] Similar discussion on channel modelling selection for JT or DPS, in Issue 2-4-1.
* Proposals
	+ Observation 1 (Ericsson, Intel, Samsung): Reception difference between two RRHs exceeds the CP with SCS=120kHz for both Scenarios A and B in the case of HST-SFN joint transmission.
	+ Proposal 1 (Intel): Define DL demodulation performance requirements only with DPS Tx scheme.
	+ Proposal 2 (Ericsson):
		- For FR2 HST UE demodulation requirements, RAN4 should define the PDSCH demodulation requirements with the assumption UE receives PDSCH only from one RRH, e.g., HST single tap, multi-path fading (TDL), or HST-DPS, with the assumption of single FFT receiver.
		- RAN4 discuss whether to define PDSCH demodulation requirements for joint transmission assuming UE is capable of multiple FFT receiver.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-2-5: DPS schemes for DL demodulation requirements (if agreed)**

* Proposals
	+ Proposal 1 (Samsung): DPS scheme 1a and 1b can be considered for PDSCH requirement in unidirectional scenario.
	+ Proposal 2 (Samsung): Only DPS scheme 1a can be considered for PDSCH requirement in bi-directional scenario.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-2-6: SCS and channel bandwidth**

* Proposals
	+ Proposal 1 (Intel): Define requirement only with 120kHz SCS and 100MHz CBW.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-2-7: UE frequency error**

* Proposals
	+ Proposal 1 (Intel): Analyse impact of UE frequency error on DL demodulation performance and after that conclude on necessity of explicit modelling of UE frequency error during the test procedure.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-2-8: Other simulation assumption for PDSCH**

* Proposals
	+ Proposal 1 (Huawei): Define PDSCH performance requirement with:

|  |  |
| --- | --- |
| Parameter | Value |
| Maximum Doppler | 9596Hz |
| Channel model | single-tap, DPS |
| CBW/SCS | 100MHz/120kHz |
| PDSCH mapping | Type A, start symbol 1, duration 13 |
| DMRS | 1+1+1 |
| PTRS | KPTRS=2, LPTRS=1 |
| Antenna configuration | 2x2 |
| MCS | 17 |
| Test metric | 70% of maximum throughput |

* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 3-3 BS Demodulation Requirement

*Sub-topic description*

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

**Issue 3-3-1: General test scope for UL requirements**

* Proposals
	+ Proposal 1 (Samsung, Intel, Huawei, E///, Nokia):
		- PUSCH
		- PUSCH with UL timing adjustment
		- PRACH requirement
	+ Proposal 2 (Samsung, Intel):
		- No PUCCH requirement for FR2 HST scenario.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-2: Test Setup for PUSCH requirement (if agreed)**

**Issue 3-3-2-1: Requirement for scenario A or B**

* Proposals
	+ Proposal 1 (Intel): Define UL demodulation performance requirements only with one deployment scenario (A or B).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-2-2: Requirement for uni-and bi-directional RRH deployment scenarios**

* Proposals
	+ Proposal 1 (Samsung): if needed to define PUSCH requirement with both RRH deployment scenarios, applicability rule can be further discussed.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-2-3: Waveform for PUSCH requirement**

* Proposals
	+ Proposal 1 (Intel, Nokia, Samsung): Define UL demodulation performance requirements only with transform precoding disabled.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-2-4: SCS & BW**

* Proposals
	+ Proposal 1 (Intel): Define UL demodulation performance requirements only with 120 kHz SCS and consider 50, 100 and 200 MHz CBW.
	+ Proposal 2 (Samsung): 120 KHz SCS, 100 MHz CBW.
	+ Proposal 3 (Huawei): one typical CBW, e.g., 200MHz.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-2-5: Antenna configuration**

* Proposals
	+ Proposal 1 (Samsung): Antenna configuration: 1Tx 2Rx low
	+ Proposal 2 (Nokia): Only have 2Rx requirements
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-2-6: Whether to define different set of PUSCH requirement to cover different FO compensation implementation**

* Proposals
	+ Proposal 1 (Intel): Define different sets of UL requirements to cover different frequency offset compensation implementations (pre-FFT and post-FFT processing).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-2-7: Other assumption for PUSCH demodulation requirement**

* Proposals
	+ Proposal 1 (Samsung): Check the PUSCH demod performance with simulation with the following setup.
		- Resource mapping type: type B
		- Length of data symbol: 9
		- MCS: 16
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-3: Test Setup for UL timing adjustment requirement**

**Issue 3-3-3-1: Test Scenario**

* Proposals
	+ Proposal 1 (Intel, Huawei, Samsung): scenario Y
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

 **Issue 3-3-3-2: Simulation Assumption for scenario Y (if agreed)**

* Proposals
	+ Proposal 1 (Huawei):

|  |  |
| --- | --- |
| Parameter | Value |
| Channel model | Stationary UE: AWGN, Moving UE: AWGN |
| UE speed | 350 km/h |
| CP length | Normal |
| A | 1.25 μs |
| Δω | 1.04 s-1 |
| MCS | 16 |
| CBW | 200MHz |
| PUSCH resource allocation | 0 to 65 RB for moving UE, 66 to 131 for stationary UE |
| SRS resource allocation | last symbol in slot #3 in radio frames, CSRS = 33, BSRS =0, for 132 RB |

* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-4: Test Setup for PRACH requirement (if agreed)**

**Issue 3-3-4-1: PRACH Formats**

* Proposals
	+ Proposal 1 (Ericsson): A2, A3, B4, C2
	+ Proposal 2 (Samsung, Huawei): C2,
	+ Proposal 3 (Intel, Nokia): A2, B4, C2
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-4-2: Channel**

* Proposals
	+ Proposal 1 (Ericsson): AWGN, and/or TDL-A (if needed);
	+ Proposal 2 (Samsung): AWGN
	+ Proposal 3 (Nokia): Limit channel model to AWGN with frequency offset decided by maximum observable doppler shift.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-4-3: Frequency offset**

* Proposals
	+ Proposal 1 (Samsung): align with PUSCH
	+ Proposal 2 (Intel): 9722Hz with 350km/h
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-3-4-4: Test Preamble Configuration**

* Proposals for NCS
	+ Proposal 1 (Ericsson): NCS = 0
	+ Proposal 2 (Samsung, Huawei, Intel, Nokia): NCS = 69
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 3-4 Testability Aspects

*Sub-topic description*

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

**Issue 3-4-1: Testability issues for FR2 HST UE**

* Proposals
	+ Proposal 1 (Qualcomm): RAN4 to discuss on the impact of the assumptions of a static UE and single probe OTA chambers on the FR2 high speed train demodulation test design;
	+ Proposal 2 (Qualcomm): For the definition of radiated demodulation requirements for FR2 HST, RAN4 should keep into account the testability of high power devices inside OTA chambers.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

Sub topic 2-1

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |

Sub topic 2-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |

Sub topic 3-1-1

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | We share the observation that FOE is not feasible with DM-RS without PT-RS. The PT-RS density should be sufficient that the receiver can perform FOE based on PT-RS (i.e. PT-RS density 2 for 350 km/h). |
| Intel | All companies concluded that PTRS is needed to support 350 km/h. We should agree that PTRS is transmitted during the test.  |
| Nokia, Nokia Shanghai Bell | **Issue 3-1-1: Uplink maximum speed feasibility study and requested RS configuration****Issue 3-1-2: Downlink maximum speed feasibility study and requested RS configuration**The important point is that the use of PT-RS is essential both in UL and DL directions to support 350 km/h.Another question, if 350 kmp/h speed needs to be supported as such. Operator’s input would be helpful to decide.**Issue 3-1-3: Carrier frequency for Doppler frequency calculation** Both Proposals 1 and 3 are OK for us. |

Sub topic 3-1-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | Since PT-RS and DMRS are transmitted only when PDSCH is transmitted, we prefer to use TRP for frequency tracking. According to the analysis, it is possible to support 350km/h at 30GHz with TRS with SCS=120kHz. For the PDSCH demodulation, two additional DMRS can compensate the phase rotation caused by Doppler shift. However if it is for the dedicated UE and UE knows it is single tap channel model (bidirectional and/or unidirectional), single DMRS can also compensate the phrase rotation. RAN4 should also capture this scenario in the demodulation requirements.  |
| Intel | We do not need agreement on baseline RS for frequency offset tracking since even with TRS we can support 350 km/h considering also UE frequency tracking error. Using of DMRS/PTRS in addition should be up to implementation.  |

Sub topic 3-1-3

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | Proposal 3. We should follow the WID.  |
| Intel | Support Proposal 3 to align with WID. |

Sub topic 3-2-1

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | Both proposals are fine (define PDSCH and not define PDCCH) |
| Intel | We support both proposals.  |

Sub topic 3-2-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | We should discuss it after we finalize the scope of UE demodulation requirements for FR2 HST.  |
| Intel | We support proposal to discuss applicability rule between bi/uni-directional scenarios if both will be introduced.  |

Sub topic 3-2-3

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | Requirements can defined with the worst case of the two scenarios |

Sub topic 3-2-4

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | Proposal 2. We are also fine to exclude the joint transmission.  |
| Intel | We do not think that JT is suitable Tx scheme for HST FR2 and prefer to define requirements only for DPS.  |

Sub topic 3-2-5

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | We can discuss it after we decide bidirectional and/or unidirectional deployment.  |
| Intel | Support both proposals. It is not feasible to consider DPS scheme 1b in bidirectional deployment under assumption of one active panel on CPE side. |

Sub topic 3-2-6

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | OK with proposal 1. |

Sub topic 3-2-7

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | We think it is up to UE implementation similarly to phase noise model. |
| Intel | We need to agree whether we need to consider UE frequency error as additional frequency offset for testing setup. We expect that there will be no difference since UE can use pre-FFT frequency offset correction and additional frequency offset on top of the Doppler shift will not cause baseband performance degradation. Same time it is better to check further the impact of frequency offset and conclude do we need to model it or not.  |

Sub topic 3-2-8

|  |  |
| --- | --- |
| Company | Comments |
| Ericsson | Regarding the parameters in Proposal 1, maximum Doppler should depends on the carrier frequency since we believe 9596Hz is derived based on fc=29.5GHz. We prefer to consider single DMRS case for HST single tap. For HST single-tap, antenna configuration should be 1x2 if we follow FR1 HST single tap.  |
| Intel |

|  |  |
| --- | --- |
| Parameter | Value |
| Maximum Doppler | 9596Hz |
| Channel model | single-tap, DPS |
| CBW/SCS | 100MHz/120kHz |
| PDSCH mapping | Type A, start symbol 1, duration 13 |
| DMRS | 1+1+1 |
| PTRS | KPTRS=2, LPTRS=1 |
| Antenna configuration | 2x2 |
| MCS | 17 |
| Test metric | 70% of maximum throughput |

Maximum Doppler frequency can be updated according to issue 3-1-3. Exact channel model is still under discussion. As for DMRS configuration we agree to consider 2 additional DMRS symbols which is baseline assumption for HST operation.  |

Sub topic 3-3-1

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | **Issue 3-3-1: General test scope for UL requirements**Agree proposal 1 and 2.  |
| Intel | Support both proposals. |
| Nokia, Nokia Shanghai Bell | **Issue 3-3-1: General test scope for UL requirements**Both proposal 1 and 2 are OK. |

Sub topic 3-3-2

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | **Issue 3-3-2-1: Requirement for scenario A or B** Agree proposal 1; we can define requirements based on the worst case scenario for demodulation.**Issue 3-3-2-2: Requirement for uni-and bi-directional RRH deployment scenarios**We have not seen any benefit from bi-directional. If there are multi panels ad BS and UE, it is better to operate uni-directional in both directions. Before creating requirements, we should clarify gain.Is the requirement impact basically Doppler reversal or not ?**Issue 3-3-2-3: Waveform for PUSCH requirement**Agree proposal 1.**Issue 3-3-2-5: Antenna configuration**Agree proposals 1 & 2.**Issue 3-3-2-7: Other assumption for PUSCH demodulation requirement**The parameters are OK |
| Intel | **Issue 3-3-2-2: Requirement for uni-and bi-directional RRH deployment scenarios**We support proposal to discuss applicability rule between bi/uni-directional scenarios if both will be introduced. **Issue 3-3-2-3: Waveform for PUSCH requirement**Since only one type of UE is assumed for which it is suitable to consider only CP-OFDM waveform we do not need to consider DFT-S-OFDM waveform for requirements definition.**Issue 3-3-2-4: SCS & BW**Excluding 50 MHz from proposal 1 is also fine for us. We can consider only typical configurations for requirements definition based on companies’ inputs.**Issue 3-3-2-5: Antenna configuration**Support both proposals.**Issue 3-3-2-6: Whether to define different set of PUSCH requirement to cover different FO compensation implementation**Pre-FFT and Post-FFT processing at BS side is to possible approaches for HST FR2 scenario when number of served UEs is quite limited. Each of them leads to different UL performance and based on our observations post-FFT cannot guarantee 64QAM operation with 350 km/h UE speed. In this case we suggest defining to set of requirements one with 16QAM and another one with 64QAM and make 64QAM requirements up to BS declaration. In this case RAN4 will guarantee minimum performance in HST FR as well as 64QAM operation.**Issue 3-3-2-7: Other assumption for PUSCH demodulation requirement**We also suggest considering 64QAM (MCS 17) in order to check issue related to different possible BS implementations. |
| Nokia, Nokia Shanghai Bell | **Issue 3-3-2-1: Requirement for scenario A or B**In FR1 HST, both scenarios with RRH close (tunnel) and further always from the railways track were tested explicitly. However, the proposal might make sense to reduce the testing burden. We need to study further which of the scenarios is more challenging from the demodulation point of view.**Issue 3-3-2-2: Requirement for uni-and bi-directional RRH deployment scenarios**The testing of equipment that supports only one type of deployment scenario cannot be enforced all scenarios. Hence, we agree with the proposal.**Issue 3-3-2-4: SCS & BW**In our opinion, we need to test 50 MHz CBW to support minimal requirements. Above that, either 100 MHz or 200 MHz CBS can be tested.**Issue 3-3-2-5: Antenna configuration**Proposal 1 is also OK.**Issue 3-3-2-6: Whether to define different set of PUSCH requirement to cover different FO compensation implementation**In our understanding, FO compensation realisation if fully implementation issue. Requirements should assume any implementation. Hence, we do not need to defined different set of requirements in this case.**Issue 3-3-2-7: Other assumption for PUSCH demodulation requirement**The parameters are fine but what is the difference to the parameters agreed in the previous meeting for PUSCH maximum supported speed evaluation? |

Sub topic 3-3-3

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| **Company** | **Comments** |
| Ericsson | **Issue 3-3-3-1: Test Scenario** Agree proposal 1 **Issue 3-3-3-2: Simulation Assumption for scenario Y (if agreed)**Proposed parameters are Ok**Issue 3-3-4-1: PRACH Formats**C2 is the most important to include**Issue 3-3-4-2: Channel**AWGN only is OK (proposal 2)**Issue 3-3-4-3: Frequency offset** Proposal 1 is OK to align with PUSCH**Issue 3-3-4-4: Test Preamble Configuration**We should double check that the test preamble is not an outlier case |
| Intel | **Issue 3-3-3-2: Simulation Assumption for scenario Y (if agreed)**Channel BW and MCS value depends on outcome of issues 3-3-2-4 and 3-3-2-7.**Issue 3-3-4-1: PRACH Formats**Support proposal 2 given that only format C2 with 120 kHz SCS can provide enough coverage for deployments with 700m inter-site distance.**Issue 3-3-4-2: Channel**Support Option 3. We do not see necessity to introduce requirements with fading channel model. Frequency offset should be considered to model HST conditions.**Issue 3-3-4-3: Frequency offset** In general, we support proposal 1 but 9722 Hz value was derived under assumption of 350km/h UE speed and 30 GHz carrier frequency that we believe will be adopted for PUSCH.**Issue 3-3-4-4: Test Preamble Configuration**Proposal 2 is based on exiting PRACH requirements for 120 km/h. We think we can reuse same assumptions for HST.  |
| Nokia, Nokia Shanghai Bell | **Issue 3-3-3-1: Test Scenario** We agree with Proposal l.**Issue 3-3-3-2: Simulation Assumption for scenario Y (if agreed)**In general, the simulation assumptions looks fine. However, it is necessary to wait until is is finally agreed that 350 km/h is maximum UE speed in HST FR2 deployment, and discuss what CBW to be tested, e.g. 100MHz vs 200 MHz.**Issue 3-3-4-2: Channel**Proposals 2 is OK as well.**Issue 3-3-4-3: Frequency offset** Proposal 1 is fine. |

Sub topic 3-4-1

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| **Company** | **Comments** |
| Ericsson | For proposal 1, maybe we can assume two probes in chamber, as RRM assumes 2AoA tests.For proposal 2, it depends on UE RF discussion, but we don’t think the max UE Tx power should not exceed PC1. In this case, we assume FR2 HST device can be tested in chamber.  |
| Intel | Only static UE and single probe can be assumed for performance requirements verification. Demodulation testing should not assume exact modeling of real field scenario. We think that baseband processing can be effectively verified with current test methodology. Definitely, beam management performance is very important aspect, but it will be guaranteed by RRM requirements. We can think of combined set of RRM and Demod requirements as a single feature to support HST FR2 operation.  |
| Nokia, Nokia Shanghai Bell | Regarding proposal 1, DPS scheme should not be a problem. For SFN scheme, when several geographically distributed TRPs are modelled, we think that it might be still possible to go with a single probe if the simulator setup is capable enough.Regarding proposal 2, we think that the power will not go above 20 dB that is acceptable for OTA chambers. |

### CRs/TPs comments collection

*N.A because no CRs/TPs submitted under Topic-2 related AIs.*

## 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.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

### CRs/TPs

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

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
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Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
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Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents