**3GPP TSG-RAN WG4 Meeting # 98-e R4-20xxxxx**

**Electronic Meeting, Jan. 25 - Feb. 5, 2021**

**Agenda item:** 11.7.1, 11.7.2, 11.7.3

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for [98e][141] NR\_HST\_FR2\_enh

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion 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-202538]), with the following objectives for core part:

|  |
| --- |
| * This WI is specifying requirements for the following scenario(s)   + NR SA single carrier scenario in FR2   + Focused on train roof-mounted high-power devices     - Single panel, i.e. only one active antenna panel at a time, as baseline antenna assumption   + The target applicable frequency is up to 30GHz. The candidate frequency bands including band n261, n257 and n258. Target deployment scenario is multi-RRHs share the same cell-ID, the detailed parameters will be investigated and decided in initial phase of WI:     - Number of RRHs per cell     - The distance between adjacent RRHs     - The distance between RRHs and railway track     - The number of SSB per RRH   + Further study the channel model for FR2 HST     - HST single Tap channel and uni/bi-directional SFN channel shall be studied     - Other channel model is not precluded     - Note: whether to introduce single tap channel model and/or SFN channel model will be decided based on further study of channel model for FR2 HST   + The maximum Doppler frequency will be investigated and determined based on operating frequency, velocity and the Rel-15/16 NR design limitations for all UL/DL physical channels.     - The feasibility of supporting speeds of up to a maximum of 350km/h will be investigated. The actual maximum supported velocity in Rel-16 FR2 frequency bands will be decided in this WI. * Specify the UE RF core requirements for power class 4 if identified   + Introduction for beam correspondence requirements for PC4 if identified * Study and specify the UE RRM core requirements   + Phase 1: Study and identify RRM requirements impacts and possible enhancement for     - Idle/inactive mode cell reselection requirements enhancement     - Connected mode requirements       * Handover delay requirement       * Measurement requirements including both L1 and SSB based L3 measurement       * Beam management requirements including beam failure detection, candidate beam detection performance requirements       * Other requirements if identified   + Phase 2: Specify enhanced RRM requirements based on outcome of Stage 1 |

Based on the agreement captured in WF [R4-2017828], companies are encouraged to further study the FR2 HST deployment scenario, channel modelling and feasibility evaluation accordingly. Furthermore, UE RF requirement should be further discussed.

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

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

As the rapporteur for FR2 HST WI, we would like to suggest the following candidate target of 1st and 2nd round email discussion:

* 1st round: Further discussion on FR2 HST deployment scenario and UE RF requirements.
* 2nd round: Approve work plan based on companies’ input and comment, and based on results from 1st round, achieve agreements as much as possible for HST deployment scenarios and UE RF requirements, as the basis for future discussion.

# Topic #1: General

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2102266 | Nokia, Nokia Shanghai Bell, Samsung | Updated Technical Report TR38.854. |

## 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: Technical Report Update

[Moderator] In this meeting, Nokia (rapporteur of TR 38.854) propose a TP to update TR based on last meeting’s agreement. Detailed discussion will be conducted in the following TP comments collection subsection 1.3.2. If companies identify other general issues for TR, it is encouraged to listed here to draw companies’ attention.

## Companies views’ collection for 1st round

### Open issues

[Moderator] N/A because it is expected companies will comment TP in the sub-section 1.3.2.

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2102266  (TP to TR 38.854) | Ericsson: One General comment on the TR, we do not think that the contents of WF should be copied into the TR. The TR should be used to capture the background for agreements once the agreements are made |
| ZTE: For introduction part, it seems from objectives of WID file. Perhaps the justification of WID file should be enough. In addition, we have similar general comment as Ericsson. Non-open-issue agreements are intended in the TR, not WF from each meeting. |
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## 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:* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

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

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| --- | --- |
| **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)

## Summary on 2nd round (if applicable)

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

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

# Topic #2: High Speed Train Deployment Scenario in FR2

*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** |
| R4-2102103 | Ericsson | Proposal 1: Use the parameters in tables 2 and 3 for checking the maximum supportable speed from a demodulation perspective. Parameters to be re-discussed for setting demodulation requirements.  Table 2: PUSCH parameters for evaluating maximum supportable speed   |  |  |  | | --- | --- | --- | | Parameter | | Value | | Transform precoding | | Disabled | | Default TDD UL-DL pattern (Note 1) | | 60 kHz and 120kHz SCS:  3D1S1U, S=10D:2G:2U | | Antenna layout | | 1T2R | | HARQ | Maximum number of HARQ transmissions | 4 | | RV sequence | 0, 2, 3, 1 | | DM-RS | DM-RS configuration type | 1 | | DM-RS duration | single-symbol DM-RS | | Additional DM-RS symbols | pos1, pos2 | | Number of DM-RS CDM group(s) without data | 2 | | Ratio of PUSCH EPRE to DM-RS EPRE | -3 dB | | DM-RS port(s) | 0 | | DM-RS sequence generation | NID=0, nSCID =0 | | Time domain resource | PUSCH mapping type | B | | Start symbol index | 0 | | Allocation length | 8 or 9 | | Frequency domain resource | RB assignment | Full applicable test bandwidth | | Frequency hopping | Disabled | | Bandwidth | 100 MHz | | Code block group based PUSCH transmission | | Disabled | | PT-RS configuration | Frequency density (*KPT-RS*) | Disabled | | Time density (*LPT-RS*) | Disabled | | MCS | | MCS16 | | Propagation channel | | Single Tap |   Table 3: PUSCH parameters for evaluating maximum supportable speed   |  |  |  |  | | --- | --- | --- | --- | | **Parameter** | | **Unit** | **Value** | | CBW and SCS | |  | 120kHz, 100MHz (66PRB) | | Duplex mode | |  | TDD | | TDD pattern | |  | DDSU (FR2.120-2)  S=11D+3G+0U | | Active DL BWP index | |  | 1 | | CSI-RS for tracking | First OFDM symbol in the PRB used for CSI-RS (*l0*) |  | 6 for CSI-RS resource 1 and 3 10 for CSI-RS resource 2 and 4 | | CSI-RS offset | Slots | 4 for CSI-RS resource 1 and 2  5 for CSI-RS resource 3 and 4 | | CSI-RS periodicity | Slots | 80 (10ms) | | PDCCH configuration | Number of PDCCH candidates and aggregation levels |  | 1/AL8 | | PDSCH configuration | Mapping type |  | Type A | | *k0* |  | 0 | | Starting symbol (S) |  | 1 | | Length (L) |  | 13 | | PDSCH aggregation factor |  | 1 | | PRB bundling type |  | Static | | PRB bundling size |  | 2 | | Resource allocation type |  | Type 0 | | RBG size |  | Config2 | | VRB-to-PRB mapping type |  | Non-interleaved | | VRB-to-PRB mapping interleaver bundle size |  | N/A | | PDSCH DMRS configuration | DMRS Type |  | Type 1 | | Number of additional DMRS |  | Option 1: 1  Option 2: 2 | | Maximum number of OFDM symbols for DL front loaded DMRS |  | 1 | | Propagation channel | |  | HST Single tap (TS38.101-4 B.3) | | Antenna configuration | |  | 1x2 | | Number of MIMO layers | |  | 1 | | MCS | |  | Option 1: 16QAM 0.5 (MCS 13 with Table 1)  Other options are not excluded | |
| R4-2100631 | Qualcomm, Inc. | Proposal 1: The following parameters need to be determined jointly to ensure beam management and mobility are feasible in FR2 HST system design:  (1) Ds, Dmin, D\_RRH\_height, D\_UE\_height: determines the angular change range to be covered by all beams  (2) RRH antenna array parameters (Mg, Ng, M, N, P): determines how large each beam can cover in angular domain  (3) Beam dwelling time and overlapping: need to support the mobility according to train speed, based on RAN4 requirement (with possible enhancement)  (4) Number of beams: this should be derived based on the above three items, angular change range, beam coverage in angular domain, beam overlapping and dwelling time  Proposal 2: The following issues should be bundled with uni-directional and bi-directional model discussion:  (1) RRH antenna array orientation  (2) Number of panels per RRH and per CPE  Observation 1: Comparison of uni-directional and bi-directional models are listed in the following table:   |  |  |  | | --- | --- | --- | |  | Uni-directional | Bi-directional | | 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 | | TCI state (if different TCI states are configured for different RRHs) | TCI state switch happens on the RRH location | TCI state switch happens at the midpoint between two RRHs | | Path loss | In the range of path length [0,Ds] | In the range of path length [0,Ds/2] |   Proposal 3: Using different SSB indexes for consecutive RRHs. |
| R4-2100915 | Samsung | FR2 HST deployment scenario:  Observation-1: FR2 HST deployment schemes which are not compatible with Rel-15/16 NR shall be precluded in FR2 HST WI discussion.  Proposal-1: For Joint transmission (JT) used for FR2 HST, only full SFN (i.e., Joint Transmission (JT) for all channels (SSB, TRS, PDCCH/PDSCH, etc)) is considered in Rel-17 FR2 HST WI.  Proposal-2: The scheme of Joint transmission (JT) for selected channels but distributed SSB shall be precluded from Rel-17 FR2 HST WI discussion.  Observation-2: For uni-directional RRH deployment, we found no benefits from Joint transmission (JT) unless there is just one fixed beamforming used in each RRH.  Observation-3: For uni-directional RRH deployment, the DPS transmission which requires UE to track more than 2 TCI states should be precluded from FR2 HST WI discussion.  Observation-4: The benefit of implementing multi-DCI based multi-TRxP transmission compared with DPS transmission 1b is not observed.  Observation-5: For bi-directional RRH deployment, joint transmission (JT) for all channels (SSB, TRS, PDCCH/PDSCH) should be precluded from using for FR2 HST.  Observation-6: For bi-directional RRH deployment, the DPS transmission which requires UE to track more than 2 TCI states should be precluded from FR2 HST WI discussion.  Channel Modeling:  Observation-7: Based on measurement campaign at 28GHz for typical railway environment, TS38.901 RMa LoS model is demonstrated to be the most accurate pathloss model in terms of lowest RMSE.  Proposal-3: RAN4 choose TS38.901 RMa LoS pathloss model used for link budget evaluation.  Observation-8: Depending on the allowed FR2 HST scenarios in Rel-17 FR2 HST WI, multi-Tap model shall be adopted if joint-transmission from neighboring RRHs are allowed, while single-Tap model shall be adopted if DPS is utilized.  Obervation-9: Based on measurement-data-calibrated ray-tracing modeling at 28GHz for typical railway environment, it has been validated that the single-tap can be assumed for a single TX-RX link.  Maximum Supported Speed:  Proposal 4: For the analysis on maximum supported Doppler shift for both UL and DL and maximum supported UE speed, it is adopted to have 120kHz Subcarrier Spacing for the HST system.  Observation 10: Downlink TRS (4 symbol interval) could support 270km/h in bi-directional channel model and double theoretically in uni-directional channel model and single tap channel.  Observation 11: For DM-RS, the supported maximum UE speed can be up to 270km/h for UE mandatory supported 3 DMRS configuration, and up to 360 km/h for UE optional supported 4 DMRS configuration.  Observation 12: For PT-RS, the minimum adjacent PT-RS symbol interval is 1, which gives the highest Doppler shift value as compared with adjacent PT-RS symbol interval is 2/4.  Proposal 5: Considering the limitation from both UL/DL PHY channel in Rel-15/16, the maximum supported UE speed with 270km/h under the assumption of carrier frequency 28GHz and 252 km/h under the assumption of carrier frequency 30GHz can be considered as starting point for RAN4 evaluation. |
| R4-2100916 | Samsung | For uni-directional RRH deployment:  Proposal 1: For uni-directional RRH deployment, the following Scenario-2 with the other parameters are chosen as the default scenario for feasibility analysis.  Table 2.1-2 Common Parameters for Uni-directional Cases   |  |  | | --- | --- | | Parameter | Value | | Dmin | 10 m | | Ds | 650 m | | RRH height | 15 m | | Number of RRH sites per BBU | 4 | | Number of RRH panels per RRH sites | 1 (i.e., uni-directional) | | Number of Analog Beams per RRH | 1 or 2 | | RRH panel orientation | Azimuth angle: 0.9 degree  Down-titling: 1.3 degree  (i.e., RRH panel boresight pointed to the railway at the distance of Ds (projection of the neighboring RRH on the railway)) |   Observation 1: For uni-directional RRH deployment, even with single analog beam per RRH, there is still around 30dB margin compared against PC4 REFSENS requirement.  Observation 2: For uni-directional RRH deployment, with two analog beams configured per RRH panel for DPS scheme, better performance can be obtained for the track area near its own RRH site, compared with single-beam-per-RRH scenarios.  For bi-directional RRH deployment:  Proposal 2: For bi-directional RRH deployment, the following Scenario-2 and 4 with the other parameters are chosen as the default scenario for feasibility analysis.  Table 3.1-2 Common Parameters for Bi-directional Cases   |  |  |  | | --- | --- | --- | | **Parameter** | **Value** | | | Ds and Dmin | Scenario-2: Ds = 650m and Dmin = 10m  Scenario-4: Ds = 300m and Dmin = 50m | | RRH height | 15 m | | | Number of RRH sites per BBU | 4 | | | Number of RRH panels per RRH sites | 2 (i.e., bi-directional) | | Number of Analog Beams per RRH | 2 | | | RRH panel orientation | Scenario-2: Azimuth angle: 1.8 degree  Down-titling: 2.6 degree  Scenario-4: Azimuth angle: 18.4 degree  Down-titling: 5.4 degree  (i.e., RRH panel boresight pointed to the railway in the middle point between 2 RRHs) |   Observation 3: For bi-directional RRH deployment with Sceanrio-2 (Ds = 650m and Dmin =10m) and Sceanrio-4 (Ds = 300m and Dmin =50m), it is hard to have satisfactory signal strength in the train track area around each RRH site. |
| R4-2101267 | Intel Corporation | Proposal #1: Number of analog beams per panel per RRH can be reduced to 1.  Proposal #2: Number of analog beams per panel per UE can be reduced to 1.  Proposal #3: The UE shall inform network whether it can support bidirectional operation in high speed in FR2 by corresponding capability field.  Proposal #4: Network which operates in bidirectional mode can turn off one panel at RRHs if UE doesn’t support bidirectional operation.  Proposal #5: Study possible enhancements to reduce UL demodulation performance degradation due to baseband processing at 350 km/h UE speed and 30 GHz carrier frequency. |
| R4-2101368 | Huawei, HiSilicon | Observations:  Observation 1: for UL DM-RS 1+1+1: consider both UL and DL together and the UL limitation of max Doppler shift: the supported max velocity = 252km/h with DL fd = 7kHz and UL fd = 14kH without margin assumption of positive to negative Doppler jump.  Observation 2: Ds = 200m and 300m maybe not suitable considering the limited coverage and possible frequent handover.  Observation 3: Dmin = 10m is not within the safe distance with assumption of RRHRRH\_height = 10m, 15m or 20m.  Observation 4: Unidirectional SFN has limited DL and UL coverage, further evolution constraint for UE with 2 active beams for data receptions and the chance to happen negative to positive Doppler change  Observation 5:  - DPS mode is a good candidate to consider for FR2 HST deployment  - For UE with support of less number of active TCI states, such as 1 or 2, and less panels per RRH or less beams per panels, Figure b is candidate channel mode to consider  - For UE with support of higher number of active TCI states, such as 2 or 4, and more panels per RRH or beams per panels to achieve larger coverage, Figure c is a candidate channel mode to consider.  Our proposals:  Proposal 1: Only consider SCS 120kHz for FR2 HST evaluations and possible performance requirements definition.  Proposal 2: Consider DMRS Type 1 with 1 symbol FL DMRS and 2 additional DMRS symbols (i.e. 1+1+1) for both UL and DL max Doppler shift analysis.  Proposal 3: Consider max velocity of 250km/h and max Doppler shift 7kHz for DL and 14kHz for UL during the evaluations of HST deployment in FR2.  Proposal 4: Consider Ds=700m and Dmin=150m as one of candidate deployment scenarios for further evaluations.  Proposal 5: 4 RRHs per BBU and 1, 2 and 4 beams per panel and 1 or 2 panels in one RRH can be considered based on the deployment scenarios.  Proposal 6: Both 1 and 2 Rx panels for different UE capability should be considered.  Proposal 7: DPS transmission scheme should be considered to reduce the multi-path delay spread, reduce ICI and achieve good coverage.  Proposal 8: Consider the shared SSBs for beams from different panels  Proposal 9: 1 or 2 Rx panels and 1 Tx panel per CPE should be considered. |
| R4-2101856 | ZTE Wistron Telecom AB | Observation: All 5 non-tunnel candidate scenarios could be grouped into two groups: Group#1 for Scenario 1/2/3 and Group #2 for Scenario 4/5.  Proposal 1: Select one scenario from each group as the target deployment scenarios.  Proposal 2: Include tunnel scenario in order to guarantee deployment coverage and flexibility.  Proposal 3: Choose only one SCS for each scenario according to the corresponding Ds: 60kHz for a scenario with a larger Ds, and 120kHz for a scenario with a smaller Ds. Under this principle, set SCS as 120kHz for the selected scenario from Group #2 and tunnel scenario, and 60kHz for the selected scenario from Group #1. |
| R4-2102093 | Nokia, Nokia Shanghai Bell | Observation 1: Without inter-cell interference and/or measurement relaxation there are no significant problems observed in mobility as radio link failure and handover failure rates are very low.  Observation 2: Bi-directional RRH deployment causes more handovers to occur than uni-directional deployment leading into shorter time-of-stay in cell.  Observation 3: Multi-beam setting can be less beneficial in ISD 650 scenario where RRH distance to track is short (10 meters) compared to ISD 300 scenario with longer RRH distance to track (50 meters). |
| R4-2102099 | Nokia, Nokia Shanghai Bell | Observation 1: In HST FR2 deployment discussions, only one train moving over one railway track in one direction was considered. Moreover, such a parameter as a distance between the tracks was not introduced. We are not expecting any considerable performance between the scenarios when the RRHs are located on one side or on both sides of the track. Thus, there is no additional value in considering both scenarios.  Proposal 1: RAN4 to consider primarily HST FR2 deployment with one train moving over one railway track in one direction. RRHs are located on one side of the track.  Observation 2: In unidirectional setting, it is beneficial to orient the RRH panel boresight to the railway at the distance of Ds. More than one beam can be used. However, additional beams will provide rathe small impact on coverage and RRM KPIs. In bidirectional setting, it makes sense to point the RRH panel to the railway in the middle point between 2 RRHs. In this case, additional beams can be used to improve the coverage next to the RRH.  Proposal 2: RAN4 to focus on the following RRH parametrization in unidirectional setting: RRH panel boresight pointed to the railway at the distance of Ds, 1, 2 analog beams(s) per RRH panel.  Proposal 3: RAN4 to focus on the following RRH parametrization in bidirectional setting: RRH panel boresight pointed to the railway in the middle point between two RRHs, 1, 2, 4 analog beam(s) per RRH panel.  Observation 3: HST FR2 deployment can use the following transmission schemes:  a. Joint transmission (JT): Classical/Full SFN, with multi-DCI or with distributed reference signals  b. Dynamic point selection (DPS): with one or multiple TCI states.  DPS in not SFN scheme.  JT scheme with only one RRH per BBU is equivalent to DPS scheme.  In unidirectional scenarios only classical SFN or DPS with one TCI state transmission schemes makes sense.  Proposal 4: RAN4 to consider unidirectional setting only with one TCI state transmission schemes, i.e., classical SFN or DPS with one TCI state.  Proposal 5: RAN4 to consider both JT and DPS transmission schemes in bidirectional setting.  Proposal 6: RAN4 to decide if more than 2 configured TCI states should be analyzed.  Proposal 7: All RRHs (connected to same BBU with fiber) share the same cell ID. SSB index to beam mapping can be left to implementation.  Observation 4: CPE installed on the rooftop of the train is not power limited device. Having two antenna panels per CPE has benefits both in unidirectional and bidirectional settings.  Observation 5: It is rather possible that more than one CPE will be installed per train, e.g. in the head and tail of the train or even per each car. However, we do not expect that increasing the number of CPEs per train will have any impact on the RRM and/or demodulation pefromance.  Proposal 8: RAN4 to consider primary one CPE per train with two panels installed vertically with the boresights parallel to the railways track and oriented in opposite directions.  Observation 6: The distance between consecutive DM-RS symbols shall not be more than 2 to support reliably 350kmph train speed. Hence, 4 DM-RS symbols per slot may be needed. It is also necessary to consider the utilization of PT-RS in addition to DM-RS. Link level simulations are needed for more accurate evaluations.  Proposal 9: RAN4 to evaluate two maximum train speeds: 260 and 350 kmph with 260 kmph as a baseline due to the high DM-RS overhead at 350 kmph. |
| R4-2102104 | Ericsson | Observation 1: The antenna model parameters in Table 2-1 result in significant gain errors in the horizontal and vertical cuts, introducing horizontal error of ±6dB and vertical error of 4.5dB.  Proposal 1: The following antenna parameters shall be adopted:   |  |  | | --- | --- | | **Parameter** | **Urban macro**  **30 GHz** | | *Am* | 30 | | *SLAv* | 30 | | *3dB* | 90 | | *3dB* | 90 | | *GE,max* | 5.5 | | *LE* | 1.8 | | *N* | 16 | | *M* | 8 | | *P* | 2 | | *dv* | 0.5 | | *dh* | 0.5 |   Proposal 2: HST FR2 UE structure as well as number of HST FR2 UEs to assume per train shall be clarified.  Observation 2: Link budget considerations do not seem to constrain any of the deployment scenarios  Observation 3: In uni-directional deployment, the Doppler shift of source and target serving beams is essentially the same.  Observation 4: In bi-directional deployment, the Doppler shift of source and target serving beams has essentially the same magnitude but opposite signs.  Observation 5: In bi-directional deployment, signals with different Doppler shifts are received using separate beams. There is no mixing of signals with opposite Doppler shifts as was the case e.g. in EUTRA.  Proposal 3: Strategies for Doppler shift mitigation in bi-directional deployment shall be studied, considering that Doppler shift is related to the UE panel.  Observation 6: In bi-directional deployment, when UE is switching serving beam, source and target beams have essentially the same propagation delay and hence similar downlink timing at the UE.  Observation 7: In uni-directional deployment, when UE is switching serving beam, source and target beams have very different propagation delays, and the change in timing may exceed a cyclic prefix.  Proposal 4: Strategies for handling changes in receive timing when changing beam in uni-directional deployment shall be studied. |

## 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: Transmission Schemes for FR2 HST

*Sub-topic description:*

[Moderator] As agreed in last meeting, RAN4 needs to study transmission schemes, such as unidirectional SFN, bi-directional SFN and detailed interpretation for SFN.

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

**Issue 2-1-1: Transmission Scheme Clarification**

* [Moderator] Based on contributions from companies, suggest to use the following clarification for different transmission schemes.
  + Joint Transmission (JT) for all channels (SSB, TRS, PDCCH/PDSCH) – Full SFN;
  + Dynamic Point Selection (DPS) – based on Rel-15 beam management;
  + Multi-DCI based Multi-TRP Transmission – based on Rel-16 eMIMO.
* Other relevant proposals:
  + Proposal-1 (Samsung): FR2 HST deployment schemes which are not compatible with Rel-15/16 NR shall be precluded in FR2 HST WI discussion.
  + Proposal-2 (Samsung): For Joint transmission (JT) used for FR2 HST, only full SFN (i.e., Joint Transmission (JT) for all channels (SSB, TRS, PDCCH/PDSCH, etc)) is considered in Rel-17 FR2 HST WI. The scheme of Joint transmission (JT) for selected channels but distributed SSB shall be precluded from Rel-17 FR2 HST WI discussion.
* Recommended WF:
  + Suggest to agree with the above transmission scheme clarification, and companies’ views are collected in 1st round discussion on proposals.

**Issue 2-1-2: Scenario Clarification and Simplification**

* Proposal on further clarification of FR2 HST scenario under discussion:
  + Proposal-1 (Nokia): RAN4 to consider primarily HST FR2 deployment with one train moving over one railway track in one direction. RRHs are located on one side of the track.
  + Proposal-2 (ZTE): Select one scenario from each group as the target deployment scenarios:
    - All 5 non-tunnel candidate scenarios could be grouped into two groups: Group#1 for Scenario 1/2/3 and Group #2 for Scenario 4/5.
  + Proposal-3 (ZTE): Choose only one SCS for each scenario according to the corresponding Ds: 60kHz for a scenario with a larger Ds, and 120kHz for a scenario with a smaller Ds. Under this principle, set SCS as 120kHz for the selected scenario from Group #2 and tunnel scenario, and 60kHz for the selected scenario from Group #1.
* Recommended WF:
  + Suggest to agree with the above scenario clarification, and companies’ views are collected in 1st round discussion on proposals.

### Sub-topic 2-2: Uni-directional Deployment

*Sub-topic description:*

[Moderator] Observations and Proposals related to uni-directional deployment, based on companies’ individual feasibility analysis, views are categorized based on the subject of uni-directional deployment, and individual transmission schemes for uni-directional deployment.

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

**Issue 2-2-1: General view toward Uni-directional Deployment**

* General view towards uni-directional deployment:
  + Observation 1 (Huawei): Unidirectional SFN has limited DL and UL coverage, further evolution constraint for UE with 2 active beams for data receptions and the chance to happen negative to positive Doppler change.
  + Observation 2 (Ericsson): In uni-directional deployment, when UE is switching serving beam, source and target beams have very different propagation delays, and the change in timing may exceed a cyclic prefix. Strategies for handling changes in receive timing when changing beam in uni-directional deployment shall be studied.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-2-2: View toward JT for all channels (full SFN) for Uni-directional Deployment**

* View toward JT for all channels (full SFN):
  + Observation 1 (Samsung): For uni-directional RRH deployment, we found no benefits from Joint transmission (JT) unless there is just one fixed beamforming used in each RRH.
  + Proposal 1 (Nokia/Samsung): For full SFN, RAN4 to consider unidirectional setting only with one TCI state transmission schemes, i.e., classical SFN.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-2-3: View toward DPS for Uni-directional Deployment**

* View toward DPS:
  + Observation 1 (Samsung): For uni-directional RRH deployment, even with single analog beam per RRH, there is still around 30dB margin compared against PC4 REFSENS requirement.
  + Observation 2 (Samsung): For uni-directional RRH deployment, with two analog beams configured per RRH panel for DPS scheme, better performance can be obtained for the track area near its own RRH site, compared with single-beam-per-RRH scenarios.
  + Proposal-1 (Samsung): For uni-directional RRH deployment, the DPS transmission which requires UE to track more than 2 TCI states should be precluded from FR2 HST WI discussion.
  + Proposal-2 (Nokia): For DPS, RAN4 to consider unidirectional setting only with one TCI state transmission schemes, i.e., DPS with one TCI state.
  + Proposal 3 (Intel): It is enough to have single (fixed) operational beam both on RRH and UE sides. Number of analog beams per panel per RRH and per panel per UE can be reduced to 1.
  + Observation 3 (Nokia): Multi-beam setting can be less beneficial in ISD 650 scenario where RRH distance to track is short (10 meters) compared to ISD 300 scenario with longer RRH distance to track (50 meters).
  + Observation 4 (Nokia): Without inter-cell interference or DRX there are no significant problems observed in mobility as radio link failure and handover failure rates are very low.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-2-4: View toward Multi-DCI based Multi-TRP Transmission for Uni-directional Deployment**

* View toward Multi-DCI based Multi-TRP Transmission:
  + Observation-1 (Samsung): The benefit of implementing multi-DCI based multi-TRxP transmission compared with DPS transmission 1b is not observed.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-2-5: Evaluation Parameters Selection for Uni-directional Deployment**

* [Moderator] In last meeting’s WF, scenarios and some parameters are provided with options, and to minimize additional efforts in future evaluation (if any) to get aligned numerical analysis, companies have proposals for focused scenario and parameters.
* Proposals:
  + Proposal 1 (Samsung): For uni-directional RRH deployment, the following Scenario-2 with the other parameters are chosen as the default scenario for feasibility analysis.

Table 2.1-2 (from Samsung R4-2100916) Common Parameters for Uni-directional Cases

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | |
| Dmin | 10 m | |
| Ds | 650 m | |
| RRH height | 15 m | |
| Number of RRH sites per BBU | 4 | |
| Number of RRH panels per RRH sites | | 1 (i.e., uni-directional) |
| Number of Analog Beams per RRH | 1 or 2 | |
| RRH panel orientation | | Azimuth angle: 0.9 degree  Down-titling: 1.3 degree  (i.e., RRH panel boresight pointed to the railway at the distance of Ds (projection of the neighboring RRH on the railway)) |

* + Proposal 2 (Nokia): RAN4 to focus on the following RRH parametrization in unidirectional setting: RRH panel boresight pointed to the railway at the distance of Ds, 1, 2 analog beams(s) per RRH panel.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

### Sub-topic 2-3: Bi-directional Deployment

*Sub-topic description*

[Moderator] Observations and Proposals related to bi-directional deployment, based on companies’ individual feasibility analysis, views are categorized based on the subject of bi-directional deployment, and individual transmission schemes for bi-directional deployment.

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

**Issue 2-3-1: General view toward Bi-directional Deployment**

* General view towards bi-directional deployment:
  + Observation 1 (Nokia): Bi-directional RRH deployment causes more handovers to occur than uni-directional deployment leading into shorter time-of-stay in cell.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-3-2: View toward JT for all channels (full SFN) for Bi-directional Deployment**

* View toward JT for all channels (full SFN):
  + Proposal-1 (Samsung): For bi-directional RRH deployment, joint transmission (JT) for all channels (SSB, TRS, PDCCH/PDSCH) should be precluded from using for FR2 HST.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-3-3: View toward DPS for Bi-directional Deployment**

* View toward DPS:
  + Observation 1 (Huawei):
    - DPS mode is a good candidate to consider for FR2 HST deployment
    - For UE with support of less number of active TCI states, such as 1 or 2, and less panels per RRH or less beams per panels, Figure b (from Huawei’s R4-2101368) is candidate channel mode to consider
    - For UE with support of higher number of active TCI states, such as 2 or 4, and more panels per RRH or beams per panels to achieve larger coverage, Figure c (from Huawei’s R4-2101368) is a candidate channel mode to consider.
  + Proposal 1 (Huawei): DPS transmission scheme should be considered to reduce the multi-path delay spread, reduce ICI and achieve good coverage.
  + Observation 2 (Samsung): For bi-directional RRH deployment with Sceanrio-2 (Ds = 650m and Dmin =10m) and Sceanrio-4 (Ds = 300m and Dmin =50m), it is hard to have satisfactory signal strength in the train track area around each RRH site.
  + Observation 3 (Nokia): Multi-beam setting can be less beneficial in ISD 650 scenario where RRH distance to track is short (10 meters) compared to ISD 300 scenario with longer RRH distance to track (50 meters).
  + Observation 4 (Nokia): Without inter-cell interference or DRX there are no significant problems observed in mobility as radio link failure and handover failure rates are very low.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-3-4: View toward Multi-DCI based Multi-TRP Transmission for Bi-directional Deployment**

* Multi-DCI based Multi-TRP Transmission:
  + Observation-1 (Samsung): For bi-directional RRH deployment, the DPS transmission which requires UE to track more than 2 TCI states should be precluded from FR2 HST WI discussion.
  + Proposal-1(Nokia): RAN4 to decide if more than 2 configured TCI states should be analyzed.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-3-5: Evaluation Parameters Selection for Bi-directional Deployment**

* [Moderator] In last meeting’s WF, scenarios and some parameters are provided with options, and to minimize additional efforts in future evaluation (if any) to get aligned numerical analysis, companies have proposals for focused scenario and parameters.
* Proposals:
  + Proposal-1 (Samsung): For bi-directional RRH deployment, the following Scenario-2 and 4 with the other parameters are chosen as the default scenario for feasibility analysis.

Table 3.1-2 (from Samsung R4-2100916) Common Parameters for Bi-directional Cases

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Value** | |
| Ds and Dmin | | Scenario-2: Ds = 650m and Dmin = 10m  Scenario-4: Ds = 300m and Dmin = 50m |
| RRH height | 15 m | |
| Number of RRH sites per BBU | 4 | |
| Number of RRH panels per RRH sites | | 2 (i.e., bi-directional) |
| Number of Analog Beams per RRH | 2 | |
| RRH panel orientation | | Scenario-2: Azimuth angle: 1.8 degree  Down-titling: 2.6 degree  Scenario-4: Azimuth angle: 18.4 degree  Down-titling: 5.4 degree  (i.e., RRH panel boresight pointed to the railway in the middle point between 2 RRHs) |

* + Proposal-2 (Nokia): RAN4 to focus on the following RRH parametrization in bidirectional setting: RRH panel boresight pointed to the railway in the middle point between two RRHs, 1, 2, 4 analog beam(s) per RRH panel.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

### Sub-topic 2-4: Other Aspects in FR2 HST Feasibility Study

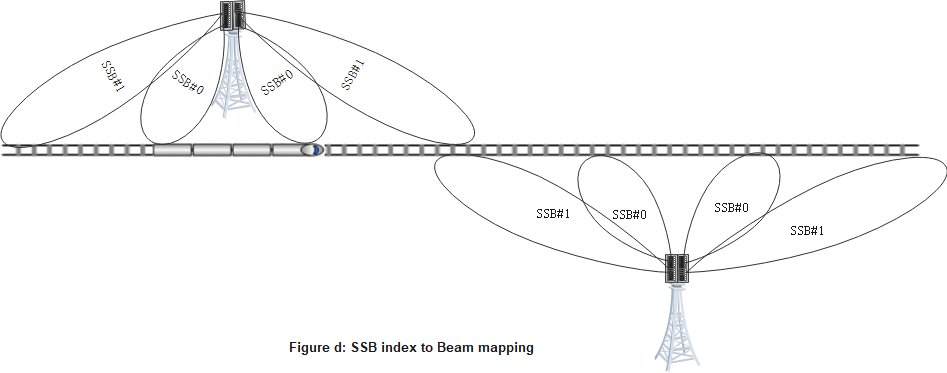
*Sub-topic description:*

[Moderator] Other aspects related to FR2 HST feasibility study.

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

**Issue 2-4-1: SSB index to Beam Mapping:**

* [Moderator] Based on last meeting WF, it is FFS the impact of following options for SSB index to Beam mapping, while companies are provided analysis accordingly.
  + Option 1:
    - All RRHs (connected to one BBU with fiber) share the same cell ID
    - All RRHs under the same cell use the same set of SSB indexes, e.g., all RRHs use SSB-0 to SSB-3. (Below figured copied from Huawei’s R4-2101368)



* + Option 2:
    - All RRHs (connected to one BBU with fiber) share the same cell ID
    - All RRHs under the same cell use the different sets of SSB indexes, e.g., RRH-1 uses SSB-0 to SSB-3, RRH-2 uses SSB-4 to SSB-7, etc.
* Proposals:
  + Proposal-1 (Huawei): Consider the shared SSBs for beams from different panels.
  + Proposal-2 (Qualcomm): Option 2.
  + Proposal-3 (Nokia): All RRHs (connected to same BBU with fiber) share the same cell ID. SSB index to beam mapping can be left to implementation.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any):**

* [Moderator] In last meeting, it is agreed to FFS the number of panels per CPE. Orientation of CPE panel is also discussed in this meeting.
* Proposals for number of panels per CPE:
  + Proposal-1 (Huawei): 1 or 2 Rx panels and 1 Tx panel per CPE should be considered.
  + Proposal-2 (Nokia): RAN4 to consider primary one CPE per train with two panels installed vertically with the boresights parallel to the railways track and oriented in opposite directions.
* Proposals for bi-directional operation for two panels (if any):
  + Proposal 1(Intel): The UE shall inform network whether it can support bidirectional operation in high speed in FR2 by corresponding capability field.
  + Proposal 2 (Intel): Network which operates in bidirectional mode can turn off one panel at RRHs if UE doesn’t support bidirectional operation.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-4-3: Number of CPE devices per train/carriage:**

* [Moderator] In last meeting, it is agreed to FFS the impact of the number of CPE per train/carriage on RAN4 requirement.
* Proposals and Observations:
  + Observation 1 (Nokia): Increasing the number of CPEs per train will not have any impact on the RRM and/or demodulation performance. RAN4 to consider primary one CPE per train.
  + Proposal2 (Ericsson): HST FR2 UE structure as well as number of HST FR2 UEs to assume per train shall be clarified.
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

**Issue 2-4-4: Tunnel Deployment Scenario**

* [Moderator] In last meeting, it is agreed to FFS tunnel deployment scenario for FR2 HST.
* Proposal:
  + Proposal (ZTE): Include tunnel scenario in order to guarantee deployment coverage and flexibility
* Recommended WF:
  + Companies’ views are collected in 1st round discussion.

### Sub-topic 2-5: FR2 HST Feasibility Evaluation Parameters Revisit

*Sub-topic description*

[Moderator] Towards the agreed parameter settings, some companies propose that some parameters and modeling can be revisited.

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

**Issue 2-5-1: Revisit FR2 HST Deployment Parameters**

* [Moderator] Observation and Proposals on revisit FR2 HST deployment parameters agreed in last meeting:
  + Observation 1 (Huawei): Ds = 200m and 300m maybe not suitable considering the limited coverage and possible frequent handover.
  + Observation 2 (Huawei): Dmin = 10m is not within the safe distance with assumption of RRH\_height = 10m, 15m or 20m
  + Proposal 1 (Huawei): Consider Ds=700m and Dmin=150m as one of candidate deployment scenarios for further evaluations.
* Recommended WF
  + Companies’ views are collected in 1st round discussion.

**Issue 2-5-2: Revisit FR2 Beamforming Modeling**

* [Moderator] In last meeting, the detailed parameters are agreed for beamforming modelling, which is aligned with TR38.803, and proposals are given for revisit some of parameters for better match with practical implementation accurately.
  + Observation 1 (Ericsson): The antenna model parameters in Table 2-1 result in significant gain errors in the horizontal and vertical cuts, introducing horizontal error of ±6dB and vertical error of 4.5dB.
  + Proposal 1 (Ericsson): The following antenna parameters shall be adopted:

|  |  |
| --- | --- |
| **Parameter** | **Urban macro**  **30 GHz** |
| *Am* | 30 |
| *SLAv* | 30 |
| *3dB* | 90 |
| *3dB* | 90 |
| *GE,max* | 5.5 |
| *LE* | 1.8 |
| *N* | 16 |
| *M* | 8 |
| *P* | 2 |
| *dv* | 0.5 |
| *dh* | 0.5 |

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

### Sub-topic 2-6: FR2 HST Channel Modeling

*Sub-topic description*

[Moderator] FR2 HST channel modeling related outstanding issues are listed.

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

**Issue 2-6-1: Pathloss model used for link budget evaluation**

* [Background] In last meeting, it is agreed that RAN4 further study the pathloss model to be used for link budget evaluation: (1) Option-1: TR38.901 RMa LoS (baseline option); Option-2: free space model; Option-3: TR38.901 UMa LoS.
* Observation and Proposal (Samsung):
  + Observation: Based on measurement campaign at 28GHz for typical railway environment, TS38.901 RMa LoS model is demonstrated to be the most accurate pathloss model in terms of lowest RMSE.
  + Proposal: RAN4 choose TS38.901 RMa LoS pathloss model used for link budget evaluation.
* Recommended WF
  + Companies’ views are collected in 1st round discussion.

**Issue 2-6-2: Channel modelling for performance requirements:**

* [Background] In last meeting, it is agreed that RAN4 further study the channel modeling for performance requirement: Option 1: single-tap per RRH channel model in UL direction and both single- and multi-tap models in DL direction; Other options are not precluded, which could depends on deployment scenario discussion.
* Observation (Samsung):
  + Option 1: Based on measurement-data-calibrated ray-tracing modeling at 28GHz for typical railway environment, it has been validated that the single-tap can be assumed for a single TX-RX link.
* Recommended WF
  + Companies’ views are collected in 1st round discussion.

### Sub-topic 2-7: Maximum Supported Speed

*Sub-topic description*

[Moderator] Based upon WID, the feasibility of maximum supported speed should be studied for FR2 HST scenario.

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

**Issue 2-7-1: Numerology considered for maximum supported speed**

* Proposal:
  + Proposal 1 (Huawei/Samsung): Only consider SCS 120kHz for FR2 HST evaluations and possible performance requirements definition.
* Recommended WF
  + Companies’ views are collected in 1st round discussion.

**Issue 2-7-2: Maximum Supported Speed from DL Perspective**

* [Moderator] Observations for the maximum supported speed from DL perspective. Technically, not too much difference from observations, but just based on different assumptions on operating frequency point, the intervals between two consecutive TRS symbols and frequency error taken into account or not:
  + Observation 1 (Samsung/Huawei): Downlink TRS (4 symbol interval) could support 270km/h in bi-directional channel model and double theoretically in uni-directional channel model and single tap channel.

|  |  |  |  |
| --- | --- | --- | --- |
| Channel | Maximum frequency offset which can be compensated | Maximum UE Speed (@28 GHz) | Maximum UE Speed (@30 GHz) |
| Single tap | +/-14000 | 540km/h | 504km/h |
| Bi-directional | +/-7000 | 270km/h | 252km/h |
| Un-directional | +/-14000 | 540km/h | 504km/h |

* + Observation 2 (Ericsson): 0.1 ppm frequency error has been taken into account to give following observation based on intervals between consecutive TRS symbols:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 1 symbol | | 3 symbols | | 4 symbols | |
| 60k SCS | 120k SCS | 60k SCS | 120k SCS | 60k SCS | 120k SCS |
| Maximum Doppler kHz | 25200 | 53200 | 6533 | 15867 | 4200 | 11200 |
| Maximum speed (UE) km/h | 972 | 2052 | 252 | 612 | 162 | 432 |

* + Proposal 1 (Huawei): Consider DMRS Type 1 with 1 symbol FL DMRS and 2 additional DMRS symbols (i.e. 1+1+1) for DL max Doppler shift analysis.
  + Proposal 2 (Huawei): Consider max velocity of 250km/h and max Doppler shift 7kHz for DL during the evaluations of HST deployment in FR2.
  + Observation 3 (Intel): Due to limitations on maximum handled estimated frequency in DL unidirectional deployment with two panel UE or bidirectional deployment with single panel UE
    - For scenarios with 60 kHz:
      * System can work in scenarios with 30GHz carrier frequency and 350km/h speed only under assumption of PTRS based estimation and density of PTRS is not less than 2.
    - For scenarios with 120 kHz:
      * System can work in scenarios with 30GHz carrier frequency and 350km/h speed and frequency tracking can be performed by any DL RS.
  + Observations 4 (Intel): Due to limitations on maximum handled estimated frequency in DL bidirectional deployment with two panel UE
    - For scenarios with 60 kHz:
      * System can work in all deployments and 350km/h speed only under assumption of PTRS based estimation and density of PTRS is not less than 1.
    - For scenarios with 120 kHz:
      * System can work in all deployments and 350km/h speed only under assumption of PTRS based estimation and density of PTRS is not less than 2. With DMRS based frequency tracking and 3 additional DMRS symbols system can operate on 350 km/h UE speed in deployment #4 and #5.
* Recommended WF
  + Companies’ views are collected on the above observations in 1st round discussion.

**Issue 2-7-3: Maximum Supported Speed from UL Perspective**

* Observations for the maximum supported speed from UL perspective. Technically, not too much difference from observations, but just based on different assumptions on operating frequency point, the intervals between two consecutive TRS symbols and frequency error taken into account or not:
  + Observation 1 (Samsung/Huawei): For DM-RS, the supported maximum UE speed can be up to 270km/h for UE mandatory supported 3 DMRS configuration, and up to 360 km/h for UE optional supported 4 DMRS configuration.

Table 4.2.1 (from R4-2100915) Maximum Doppler shift and maximum UE speed according to PUSCH

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| SCS (KHz) | Number of DMRS | DMRS configuration  (14 OFDM symbol, type A) | Maximum Interval of RS | Frequency Offset range | Maximum UE speed  (@28GHz) | Maximum UE speed  (@30GHz) | UE feature |
| 120 | 4 | 1+1+1+1 (2(3),5 8,11) | 0.0268ms | +/- 18657Hz | 360km/h | 336km/h | Optional with capability signalling |
| 3 | 1+1+1 (2(3),7,11) | 0.0356ms | +/- 14000Hz | 270km/h | 252km/h | Mandatory without UE capacity signalling |

* + Observation 2 (Samsung): For PT-RS, the minimum adjacent PT-RS symbol interval is 1, which gives the highest Doppler shift value as compared with adjacent PT-RS symbol interval is 2/4.

Table 4.2.2 (from R4-2100915) Maximum Doppler shift and maximum UE speed according to PT-RS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Reference signal | Symbol interval | Maximum frequency offset which can be compensated | Maximum UE Speed (@28 GHz) | Maximum UE Speed (@30 GHz) |
| PT-RS | 1 | 56000 | 1080km/h | 1008km/h |
| 2 | 28000 | 540km/h | 504km/h |
| 4 | 14000 | 270km/h | 252km/h |

* + Observation 3 (Ericsson): 0.1 ppm frequency error has been taken into account to give following observation based on intervals between consecutive DMRS symbols:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 1 symbol | | 3 symbols | | 4 symbols | |
| 60k SCS | 120k SCS | 60k SCS | 120k SCS | 60k SCS | 120k SCS |
| Maximum Doppler kHz | 25200 | 53200 | 6533 | 15867 | 4200 | 11200 |
| Maximum speed (BS) km/h | 486 | 1026 | 126 | 306 | 81 | 216 |

* + Proposal 1 (Huawei): Consider DMRS Type 1 with 1 symbol FL DMRS and 2 additional DMRS symbols (i.e. 1+1+1) for UL max Doppler shift analysis.
  + Proposal 2 (Huawei): Consider max velocity of 250km/h and max Doppler shift 14kHz for UL during the evaluations of HST deployment in FR2.
  + Observation 4 (Intel): Due to limitation on maximum handled estimated frequency error in UL
    - For scenarios with 60 kHz:
      * System can work in scenarios with 30GHz carrier frequency and 350km/h speed only when PTRS are present in every OFDM symbol.
      * Maximum theoretical supported UE speed for scenarios with 60 kHz SCS when PTRS are not present is less than 200 km/h (without taking into account UE frequency tracking error)
    - For scenarios with 120 kHz:
      * System can work in scenarios with 30GHz carrier frequency and 350km/h speed only when PTRS are present in every or in every second OFDM symbol.
      * Maximum theoretical supported UE speed for scenarios with 120 kHz SCS when PTRS are not present is less than 350 km/h (without taking into account UE frequency tracking error)
  + Observation 5 (Nokia): The distance between consecutive DM-RS symbols shall not be more than 2 to support reliably 350kmph train speed. Hence, 4 DM-RS symbols per slot may be needed. It is also necessary to consider the utilization of PT-RS in addition to DM-RS. Link level simulations are needed for more accurate evaluations.
* Recommended WF
  + Companies’ views are collected on the above observations in 1st round discussion.

**Issue 2-7-4: The necessity of checking demodulation feasibility for maximum supportable speed**

* [Moderator] Proposals for asking to further check demodulation feasibility under FR2 HST scenario:
  + Proposal 1 (Ericsson/Intel): RAN4 shall check the maximum supportable speed from demodulation perspective and accordingly the possible enhancement:
    - Intel: Enhancement to reduce UL demodulation degradation for 350kmph and 30GHz carrier frequency).
    - Ericsson: strategies for Doppler shift mitigation in bi-directional deployment, considering that Doppler shift is related to the UE panel.
  + Observation 1 (Intel): UL demodulation performance degradation due to ICI effect
    - For 60 kHz SCS Acceptable performance degradation (< 2dB) is observed only for QPSK with not higher than 260 km/h UE speed. 64QAM cannot work totally.
    - For 120 kHz SCS acceptable performance degradation (< 2dB) is observed for QPSK and 16QAM with UE speed up to 350 km/h. 64QAM can operate only up to 290 km/h but performance loss even with 200 km/h is higher than 2 dB.
  + Proposal 2 (Nokia): RAN4 to evaluate two maximum train speeds: 260 and 350 kmph with 260 kmph as a baseline due to the high DM-RS overhead at 350 kmph.
* Recommended WF
  + Companies’ views are collected in 1st round discussion on the necessity of checking demodulation feasibility for maximum supportable speed.

**Issue 2-7-5: Parameters to check demodulation feasibility for maximum supportable speed**

* [Moderator] Given the necessity of checking demodulation feasibility for maximum supportable speed is confirmed (based upon the discussion on the previous issue), proposals are provided for detailed parameters for baseband demodulation performance evaluation.
  + Proposal 1 (Ericsson): Using following parameters (Table 2, and 3 from R4-2102103) for checking the maximum supportable speed from a demodulation perspective. Parameters to be re-discussed for setting demodulation requirements.

Table 2 (from R4-2102103): PUSCH parameters for evaluating maximum supportable speed

|  |  |  |
| --- | --- | --- |
| Parameter | | Value |
| Transform precoding | | Disabled |
| Default TDD UL-DL pattern (Note 1) | | 60 kHz and 120kHz SCS:  3D1S1U, S=10D:2G:2U |
| Antenna layout | | 1T2R |
| HARQ | Maximum number of HARQ transmissions | 4 |
| RV sequence | 0, 2, 3, 1 |
| DM-RS | DM-RS configuration type | 1 |
| DM-RS duration | single-symbol DM-RS |
| Additional DM-RS symbols | pos1, pos2 |
| Number of DM-RS CDM group(s) without data | 2 |
| Ratio of PUSCH EPRE to DM-RS EPRE | -3 dB |
| DM-RS port(s) | 0 |
| DM-RS sequence generation | NID=0, nSCID =0 |
| Time domain resource | PUSCH mapping type | B |
| Start symbol index | 0 |
| Allocation length | 8 or 9 |
| Frequency domain resource | RB assignment | Full applicable test bandwidth |
| Frequency hopping | Disabled |
| Bandwidth | 100 MHz |
| Code block group based PUSCH transmission | | Disabled |
| PT-RS configuration | Frequency density (*KPT-RS*) | Disabled |
| Time density (*LPT-RS*) | Disabled |
| MCS | | MCS16 |
| Propagation channel | | Single Tap |

Table 3 (from R4-2102103): PUSCH parameters for evaluating maximum supportable speed

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | | **Unit** | **Value** |
| CBW and SCS | |  | 120kHz, 100MHz (66PRB) |
| Duplex mode | |  | TDD |
| TDD pattern | |  | DDSU (FR2.120-2)  S=11D+3G+0U |
| Active DL BWP index | |  | 1 |
| CSI-RS for tracking | First OFDM symbol in the PRB used for CSI-RS (*l0*) |  | 6 for CSI-RS resource 1 and 3 10 for CSI-RS resource 2 and 4 |
| CSI-RS offset | Slots | 4 for CSI-RS resource 1 and 2  5 for CSI-RS resource 3 and 4 |
| CSI-RS periodicity | Slots | 80 (10ms) |
| PDCCH configuration | Number of PDCCH candidates and aggregation levels |  | 1/AL8 |
| PDSCH configuration | Mapping type |  | Type A |
| *k0* |  | 0 |
| Starting symbol (S) |  | 1 |
| Length (L) |  | 13 |
| PDSCH aggregation factor |  | 1 |
| PRB bundling type |  | Static |
| PRB bundling size |  | 2 |
| Resource allocation type |  | Type 0 |
| RBG size |  | Config2 |
| VRB-to-PRB mapping type |  | Non-interleaved |
| VRB-to-PRB mapping interleaver bundle size |  | N/A |
| PDSCH DMRS configuration | DMRS Type |  | Type 1 |
| Number of additional DMRS |  | Option 1: 1  Option 2: 2 |
| Maximum number of OFDM symbols for DL front loaded DMRS |  | 1 |
| Propagation channel | |  | HST Single tap (TS38.101-4 B.3) |
| Antenna configuration | |  | 1x2 |
| Number of MIMO layers | |  | 1 |
| MCS | |  | Option 1: 16QAM 0.5 (MCS 13 with Table 1)  Other options are not excluded |

* Recommended WF
  + Companies’ views are collected on the detailed parameters in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Sub topic 2-1: Transmission scheme clarification:  Issue 2-1-1: Transmission Scheme Clarification  - We suggest to use consider and use the terms of “Joint Transmission (JT) for all channels (SSB, TRS, PDCCH/PDSCH) – Full SFN” (abbreviated as “JT”), “Dynamic Point Selection” (abbreviated as “DPS”), and “Multi-DCI based Multi-TRP Transmission” for following discussion. But whether or not the scheme is applicable to FR2 needs FFS, which should be based on FR2’s characteristics.  - As proponent of P1 and P2, we are proposing this based on the principle that Rel-17 FR2 HST should be based on existing Rel-15/16 compatible solution while non-compatible new solution should be excluded. In other words, we don’t have the plan to discuss new RAN1/RAN2 design in this work item, which should be the common understanding.  Issue 2-1-2: Scenario Clarification and Simplification  - For Proposal-1 from Nokia: we agree with P1.  - For Proposal-2 from ZTE: we can just use the prioritized scenarios (i.e., 2 and 4) for future evaluation, while tunnel scenario can be discussed separately.  - For Proposal-3 from ZTE: as we propose for max Doppler shift and supported UE speed part, we propose to restrict the FR2 discussion to only considering 120kHz SCS.  Sub topic 2-2: Uni-directional Deployment  Issue 2-2-1: General view toward Uni-directional Deployment  - To Observation 1 from Huawei: We share different view from Huawei because at least for Rel-17, we don’t see the possibility to have 2 active beams at UE for data reception, because we don’t have this supported in Rel-15/16. It is straightforward that Rel-17 FR2 HST will be largely depends on and reuse existing UE and gNB HW and SW design as much as possible, and we can’t disfavor uni-directional design by based on some future implementation we don’t have right now.  - To Observation 2 from Ericsson: This issue can be further discussed, but if the train is moving toward the incoming signals from RRH, the RX timing is not an issue then. So one practical implementation method can be:  - Each RRH site has two panels to two directions respectively, but each panel is dedicated for the train moving in one direction; For UE, it can just active the beam toward the upcoming signal.    Issue 2-2-2: View toward JT for all channels (full SFN) for Uni-directional Deployment  - As proponent, agree with P1: based on our Observation, uni-directional full SFN with one beam direction from each RRH panel can be further discussed to see the feasibility and benefits. Uni-directional full SFN with each RRH panel having multiple beam directions should be excluded.  Issue 2-2-3: View toward DPS for Uni-directional Deployment  - For RRH side, based on our observations and also from others’ analysis, we see the necessity of restricting the discussion for having very few analog beam direction(s) for each RRH panel, e.g., one, or two.  - For UE side, we repeat our proposal-1, i.e., for uni-directional RRH deployment, the DPS transmission which requires UE to track more than 2 TCI states should be precluded from FR2 HST WI discussion.  Issue 2-2-4: View toward Multi-DCI based Multi-TRP Transmission for Uni-directional Deployment  - Don’t see benefits of having mulit-DCI based mulit-TRP TX scheme. Note: which scheme to be supported in FR2 HST scheme should depends on NW vendors’ plan, in other words, not all possible Rel-15/16 schemes should be supported for FR2 HST.  Issue 2-2-5: Evaluation Parameters Selection for Uni-directional Deployment  - Suggest to further discuss the parameters (e.g., the table proposed by Samsung) to narrow down the scenario to be evaluated in future meetings.  Sub topic 2-3: Bi-directional Deployment  Issue 2-3-1: General view toward Bi-directional Deployment  - For bi-directional deployment, beam coverage and accordingly the frequency of handover/beam switching should be reviewed together.  Issue 2-3-2: View toward JT for all channels (full SFN) for Bi-directional Deployment  - As proponent of P1, we suggest to preclude JT from bi-directional RRH deployment discussion.  Issue 2-3-3: View toward DPS for Bi-directional Deployment  - For Observation-1 from Huawei, we don’t see the necessity to consider UE with support of active TCI number larger than 2. For more than 2 beam directions per RRH panel, RAN4 should discuss feasibility based on system-level evaluation.  - For Observation-2 from us, we would like to see other companies’ view for how to avoid such coverage hole for bi-directional deployment.  For O3 and O4 from Nokia, we think the group need more discussion on evaluate the possibility of UE to do beam measurement and beam switching based on smaller number of RX beams and certain supported UE speed.  For 2-3-4: View toward Multi-DCI based Multi-TRP Transmission for Bi-directional Deployment  - Similar to uni-directional RRH deployment, we don’t see benefits of having Mulit-DCI based Mulit-TRP TX scheme. Note: which scheme to be supported in FR2 HST scheme should depends on NW vendors’ plan, in other words, not all possible Rel-15/16 schemes should be supported for FR2 HST.  Issue 2-3-5: Evaluation Parameters Selection for Bi-directional Deployment  - Suggest to further discuss the parameters (e.g., the table proposed by Samsung) to narrow down the scenario to be evaluated in future meetings.  Sub-topic 2-4: Other Aspects in FR2 HST Feasibility Study  Issue 2-4-1: SSB index to Beam Mapping:  - Agree with Option 2. As mentioned above, we don’t expect UE can have TX/RX to two directions, so we don’t see the benefits of having signals from two directions but carrying the same SSB index. Furthermore, if it is allowed to have the signals from two directions but carrying the same SSB index, then how UE RX beam can be trained? E.g., from Figure d from Huawei’s R4-2101368, if the UE (moving from left to right) is switched to SSB-1 when travel to the overlapping area from RRH-left to RRH-right, how UE is notified about SSB-1’s QCL Type-D information will be changed? In this case, even gNB want to the UE to measure the new beam, it can’t rely on SSB but use CSI-RS as the basis for new TCI. If so, all the efforts “saved” for SSB-based beam management will be done again for CSI-RS based BM instead, and the overall efforts cannot be saved at all.  Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any)  - For the number of panel per CPE: Nokia’s proposal is okay. On the other hand, we may also see the possibility of having one panel pointing to upside and have analog beam directed to forward and backward by adjusting phase-shifter array.  - For bi-directional operation for two panels (if any): We agree with P2, but we can further discuss P1 because roof-mounted-CPE is a dedicated eco-system between RRH and CPE. If UE behavior is determined like UE always work in uni-directional operatioin, then no need to have this capability field.  Issue 2-4-3: Number of CPE devices per train/carriage  - Need more clarification on P2 from Ericsson the impact, and whether or not RAN4 need to consider the case with spatial duplexing to different UEs.  Issue 2-4-4: Tunnel deployment scenario:  - Need more time to check tunnel deployment scenario. At least we see the major difference between FR1 and FR2 for tunnel scenario is leaky cable is not applicable for FR2 operation. Maybe in Rel-17 WI, major focus should be given to open air deployment scenario, rather than tunnel scenario.  Sub-topic 2-5: FR2 HST Feasibility Evaluation Parameters Revisit  Issue 2-5-1: Revisit FR2 HST Deployment Parameters  - When companies discuss the justification of FR2 HST WI, it is based on operators’ deployment scenario, and some of operators see the business opportunities to have cooperation with train companies thereby the minimum Dmin is not a restriction to them at all.  - As we discussed in last meeting, it is possible to consider multiple scenarios if companies can agree on one, and restricting to one scenario is not preferred.  Issue 2-5-2: Revisit FR2 Beamforming Modeling  - P1 is not preferred. The model used in TR38.803 is already used as basis for Rel-15 FR2 requirement discussion and RAN1 discussion, and RAN4 already have the assumption used for simulation. Need other companies’ view for whether or not the argument for 7-24GHz is also applicable for legacy FR2 bands like n261.  Sub-topic 2-6: FR2 HST Channel Modeling  Issue 2-6-1: Pathloss model used for link budget evaluation  - As proponent of Proposal, we suggest RAN4 to agree on the proposal.  Issue 2-6-2: Channel modelling for performance requirements:  - As proponent of Observation, we suggest RAN4 to agree on Option 1.  Sub-topic 2-7: Maximum Supported Speed  Issue 2-7-1: Numerology considered for maximum supported speed  - As proponent of Proposal, we suggest RAN4 to agree on the proposal 1 to save effort in following discussion.  Issue 2-7-2: Maximum Supported Speed from DL Perspective  - It is shown that downlink TRS (4 symbol interval) could support 270km/h in bi-directional channel model and double theoretically in uni-directional channel model and single tap channel. We believe UL should be the bottleneck for the supported UE speed, from baseband demodulation perspective.  Issue 2-7-3: Maximum Supported Speed from UL Perspective  - As mentioned in our Observation 2, the configuration with DMRS+PTRS should be considered, which can support higher UE speed theoretically. RAN4 can further have baseband evaluation based on DM-RS+PT-RS.  Issue 2-7-4: The necessity of checking demodulation feasibility for maximum supportable speed  - Baseband evaluation for demodulation performance can be checked in future RAN4 meeting, based on the simulation assumption to be agreed in this meeting. However, it should also be noted that the feasibility from other perspective is also needed, i.e., enough time duration for beam switching and beam measurement, considering the number of RX beams needed for UE.  Issue 2-7-5: Parameters to check demodulation feasibility for maximum supportable speed  - For DL evaluation: If the bottleneck comes from UL, the DL evaluation may not be needed, and we may like to hear other companies’ views.  - For UL evaluation: We suggest to use PT-RS (time density *LPT-RS* =1, and frequency density *KPT-RS* =2) to be enabled as the starting point, with much reduced DM-RS density (no additional symbols). The benefit is much reduced overhead with PT-RS used, and we need to evaluate the maximum speed it can support with minimum DM-RS symbol used. |
| Ericsson | **Issue 2-1-1: Transmission Scheme Clarification**  Proposal 1: We agree the scope of the discussion should be rel-15/16 functionality  Proposal 2: This is OK, although for JT on all channels this is only compatible with uni-directional and even then needs some further discussion and investigation that there are no significant effects as the UE passes an BS.  **Issue 2-1-2: Scenario Clarification and Simplification**  Proposal 1: We are OK to assume this for evaluation. There should be scope to double check if there could be any foreseen problem when 2 trains pass; in such a case it could be raised but otherwise default is assume 1 train per track. What is also important is the number of UEs per train.  Proposal 2: We are OK to group to BS close to track & BS further from track; it would be good to reduce the number of scenarios.  Proposal 3: We think SCS is related to Doppler rather than Ds. We could consider simplifying to use 120kHz SCS only.  **Issue 2-2-1: General view toward Uni-directional Deployment**  We do not see link budget restrictions for uni-directional deployment. It may be more simple to handle mobility (to be further evaluated) so it should be considered further (as well as bi-directional).  **Issue 2-2-2: View toward JT for all channels (full SFN) for Uni-directional Deployment**  JT is inly useful for uni-directional; we agree. The most optimal beamforming and whether there could be any issues as an RRH is passed for JT need some further study.  **Issue 2-2-3: View toward DPS for Uni-directional Deployment**  In general a small number of beams are likely to be needed; there should be some further discussion on the exact number to assume (depends on scenario). The number of TCI states relates to the conclusion.  **Issue 2-2-5: Evaluation Parameters Selection for Uni-directional Deployment**  We are OK to focus the scenario assumption in this way. The downtilt/azimuth angle could be left open.  **Issue 2-3-1: General view toward Bi-directional Deployment**  True bi-directional implies beam changes both at BS and in-between BS and also more issues with Doppler change etc. Further evaluation needed.  **Issue 2-3-2: View toward JT for all channels (full SFN) for Bi-directional Deployment**  Proposal 1: We agree, since panels will point in opposite directions there will be no over-the air SFN combining and JT does not make sense.  **Issue 2-3-3: View toward DPS for Bi-directional Deployment**  Whether there is an issue in passing the RRH depends on beam design, and whether the beams are optimized for mobility or optimized for coverage. This needs more investigation.  **Issue 2-3-5: Evaluation Parameters Selection for Bi-directional Deployment**  OK to narrow to 2 scenarios. We prefer the Nokia proposal to keep more options open for the number of beams; a consideration is needed whether top optimize beams for performance or mobility. We do not need to agree the azimuth/downtilt right now.  **Issue 2-4-1: SSB index to Beam Mapping:**  Care needs to be taken that the UE can realize that when configured with a new TCI state it is associated with a beam that it potentially has not measured before, even if the SSB index and cell ID is the same (TCI state known condition).  **Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any):**  Number of CPE per train: We are OK to assume 1; one question is if this is enough from a capacity point of view. If there would be more than 1 CPE per train, there could be interference scenarios.  Signalling for bi-directional operation support: One question is whether since the UE is train mounted, trains run on a specific track and the network is a dedicated network how much such capability signalling is needed for bi-directional.  **Issue 2-4-3: Number of CPE devices per train/carriage:**  The number of CPEs per train may have some impact on interference scenarios, but we are OK to assume 1 CPE/train as baseline.  **Issue 2-4-5: Tunnel Deployment Scenario**  We should have a proposal for what a tunnel scenario entails. We have not seen indications that tunnel scenarios could exist for environments in which FR2 is deployed. We raised the question to check whether such scenarios are expected. For now, we could focus on the previously agreed scenarios.  **Issue 2-5-1: Revisit FR2 HST Deployment Parameters**  We do not see coverage limitations for FR2. 10m separation can offer coverage with 1 or 2 beams from the RRH. Further distance of RRH from track may imply more beams and actually more challenging mobility. Mobility performance should be checked though.  **Issue 2-6-1: Pathloss model used for link budget evaluation**  We saw similar results for free-space and the LoS models. Proposal is OK  **Issue 2-6-2: Channel modelling for performance requirements:**  Single tap is probably OK, apart from uni-directional SFN potentially.  **Issue 2-7-1: Numerology considered for maximum supported speed**  We are OK to consider only 120kHz SCS.  **Issue 2-7-2: Maximum Supported Speed from DL Perspective**  Frequency error should be taken into account. For bi-directional, the fact that Doppler reversal is associated with panel switching can be used to enhance Doppler estimation and reduce the need for DM-RS overhead. We should check the maximum speed from a demod performance and RRM perspective, and then decide which RS pattern is needed. We note that apart from overhead, frequency estimation will not be a limiting factor.  **Issue 2-7-3: Maximum Supported Speed from UL Perspective**  Same comment as DL; of course, the UL is the limiting direction.  \*\*\* Update 2020-01-27 \*\*\*\*  **Issue 2-2-1: General view toward Uni-directional Deployment**  **Reply to Samsung:** Our understanding is that the timing jump occurs both for a train moving towards the RRH and away from it.  If moving away from the RRH, when the train passes the next RRH the UL TA will jump from maximum to zero.  If moving towards the RRH, when the train passes the RRH the UL TA will jump from zero to maximum.  Either way, the UL TA jumps.  **Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any)**  **Reply to Nokia, Samsung**: For developing requirements, we could assume 1 for uni-directional, 2 for bi-directional. It may be that more panels are included in real life (e.g. always 2), but for minimum requirements this does not matter so much.  **Issue 2-4-3: Number of CPE devices per train/carriage**  **Reply to Samsung:** The question is really about whether 1 UE per train provides enough capacity for the whole train. For this discussion though, we should just consider whether assuming >1 UE per train would impact the requirements or not. It could impact if we would have different interference situations potentially or it would impact the number of beams that can be active. Bi-directional could also provide more capacity if it would act as a different UE in each direction (like 2 times uni-direcitonal) and that would not impact requirements much.  **Issue 2-5-2: Revisit FR2 Beamforming Modeling**  **Reply to Samsung:** The problem is that the combination of 0.5 lamda and 65-degree beamwidth is physically not possible to build. If the model is assumed this way, it will provide erroneous results on the beam patterns and link budget. This is true for all frequencies (it is a geometric property of the relationship between lamda and the beamwidth). Either we need to assume 0.7 lamda spacing and 65-degree BW or 0.5 lamda spacing and 90 degree beamwidth. Horizontal and vertical can be treated independently. |
| QC | **Issue 2-1-1**  OK for proposal 1 and 2  **Issue 2-1-2**  **Proposal 1:** We don’t think it is practical to consider one direction only. We can start with consider one UE at a time, but from time to time, UE can run in different direction, as railway with two directions are usually deployed next to each other and may serve by the same RRH.  **Proposal 2:** This requires operator input too, and within each group, the pathloss and beam overlapping, which are important for RRM measurement, can be different. Hence not necessary only one within a group can be chosen.  **Proposal 3:** If the concern is CP, first we would like to know if larger Ds options really exceed CP length? And how much performance impact it has on demod performance? Also this is under the assumption that UE receives signal from two RRHs simultaneously, which is not necessary true for all the deployment options. We don’t think this restriction is necessary at this stage.  **Issue 2-2-1**  **Observation 1:** It’s not obvious to us why uni-directional SFN has limited DL and UL coverage. Unless Ds is too large, from direction perspective, after UE passed RRH for a small distance, UE is within the coverage of this RRH, until UE passed next RRH for a small distance. RRH beams are always coming from the same direction, hence UE can’t go out of coverage from angle perspective. If pathloss is too large, reduce Ds can be considered.  **Observation 2:** Timing change that UE can handle is not limited by CP, but agree that there is a large timing change and whether UE can handle it smoothly has to be considered.  **Issue 2-2-2**  **Observation 1:** Agree  **Proposal 1:** We don’t agree with the proposed restriction, since 2 TCI states can be considered to switch between consecutive RRHs (but UE doesn’t necessary to track 2 TCI state simultaneously), if it enhances reuse of spatial resources.  **Issue 2-2-3**  We generally agree that only 1 beam (both UE and RRH) is needed to cover one train in one direction under uni-directional scenario, if Dmin is small enough. If Dmin is larger, more beams will be needed. However, different TCI states across different RRH may still be possible.  **Issue 2-2-4**  Agree with the observation.  **Issue 2-2-5**  Both proposals are fine for us as a starting point, but as we analysed in our contribution, number of beams depends on the deployment scenario (angular range), beam overlapping and width, hence other options may be included in the future if performance benefits are identified.  **Issue 2-3-1**  **Observation 1:** It’s not obvious to us why bi-direction causes more handovers  **Issue 2-3-2**  **Proposal 1:** UE can steer its antenna to the strongest SSB, the other SSB from the other RRH is treated as weaker path, this may still work.  **Issue 2-3-3**  **Proposal 1:** Agree  **Observation 2:** Agree with the observation. Although UE can receive signals in the area around each RRH site, it requires a separate panel and a wide beam on it, which may not be feasible and is costly since UE already requires two panels to receive signal from front and back.  **Observation 3:** Agree  **Observation 4:** Neighboring cell measurement requirement might need to be evaluated since train speed is fast, but at the stage we agree that RLF and HO failure seems unlikely.  **Issue 2-3-5**  **Proposal 1,2:** Both proposals are fine for us as a starting point, but as we analysed in our contribution, number of beams depends on the deployment scenario (angular range), beam overlapping and width, hence other options may be included in the future if performance benefits are identified.  **Issue 2-4-1**  **Proposal 1:** We don’t agree. With SSB index shared, same SSB may have opposite Doppler shift, creating a large Doppler spread in the received signal, as we explained in our contribution  **Proposal 2**: (our proporsal)  **Proposal 3:** OK for cell ID part, but SSB from consecutive RRHs should have different indexes.  **Issue 2-4-2**  **Proposal 1**: We want to understand: are the Rx panels and Tx panels refer to physically different panels? Two or three panels (including Rx and Tx) in total? Another question is if only 1 Tx panel is used, how it covers two directions?  **Proposal 2:** This can be a starting point for discussion  **Proposal 1/2 (Intel):** Too early to discuss signalling and implementation details  **Issue 2-4-3**  **Observation 1:** fine with this proposal at current stage unless other issues are identified for multiple CPE cases in the future.  **Issue 2-4-4**  **Proposal:** Before including the scenario, the proponent should first clarify what’s the difference between tunnel and other scenario that is not captured by the options of Ds, Dmin and channel model.  **Issue 2-5-1**  The observations/proposals are derived from the analysis based on R15 requirement, however, both factors can be modified depending the deployment and beam design:   * + Sweeping Rx scaling 8 can possibly be reduced   + Beam coverage   Therefore, we still recommend operator to propose the preferred scenario, then feasibility can be evaluated according to agreed assumptions.  **Issue 2-5-2**  **Proposal 1:** Agree  **Issue 2-6-1**  **Proposal:** Agree as a starting point for study  **Issue 2-6-2**  **Observation:** Agree as a starting point for study  **Issue 2-7-1**  **Proposal:** Agree as a starting point, if aligns to deployment preference  **Issue 2-7-2**  **Observation 1 and 2**: Agree with bi-directional constraint. However, single tap and uni-directional may not have such limitation on speed for DL if UE switch beams far enough into the next RRH region. For example, if UE switches beam at the point depicted in the following figure for uni-directional model, speed limit is larger than listed in the observation.    **Proposal 1:** max Doppler shift analysis is based on UE tracking bandwidth for frequency offset, which is tracked by TRS instead of DMRS. Hence TRS configuration should be agreed for this analysis, instead of DMRS.  **Proposal 2:** as explained previously, 250km/h may be the constraint for bi-directional channel, but not single tap or uni-directional channel.  **Observation 3 and 4:** Doppler shift is not applied to UE suddenly, hence unless UE beam changes, UE doesn’t experience the frequency error increase at the scale of Doppler shift. Hence Doppler shift is not a general constraint, it depends on which scenario/channel model do we consider, and where UE switch beams. Same comment as to proposal 1 and 2, bi-directional analysis is reasonable, but may not apply to uni-directional. |
| docomo | **Issue 2-4-4: Tunnel Deployment Scenario**  We agree to include tunnel deployment scenario. In Rel-16 FR1 NR HST requirements, there are tunnel scenario and the assumption of Ds and Dmin are 300m and 2m respectively. The priority scenario which agreed last meeting has Dmin=10m in minimum and this may be too large for tunnel deployment scenario. In addition, there are a lot of running in tunnel when assuming a real operational environment so it is important to verify the performance in tunnel. Therefore, RAN4 should discuss tunnel deployment scenario including to consider appropriate assumption of Dmin.  **Issue 2-7-1: Numerology considered for maximum supported speed**  From my perspective, we are OK to consider only SCS=120kHz.  **Issue 2-7-2: Maximum Supported Speed from DL Perspective**  We have the same understanding as Observation 1 in terms of the maximum frequency offset which can be compensated by TRS (4 symbol interval). Same time, we understand that PT-RS (1 and 2 symbol interval) can compensate larger maximum frequency offset compared with TRS. In this sense, we would like to clarify which reference signals to be used for HST FR2 discussion. At the current stage, our preference is PT-RS (*LPT-RS* =1).  **Issue 2-7-3: Maximum Supported Speed from UL Perspective**  We have the same view with Maximum Doppler shift calculation results proposed by Samsung (R4-2100915). The description “Mandatory without UE capacity signalling” in column Table 4.2.1(from R4-2100915) should be attention since whether mandatory or not depends on not only DMRS configuration but also rank of transmission (when 1FL +2add + Rank 2 are adopted then UE feature is Mandatory with capability). Regarding Maximum Supported Speed, RAN4 should clarify which reference signals to be used for HST FR2. As mentioned by Intel, using PT-RS may have higher correction accuracy than using DM-RS. |
| ZTE | Issue 2-1-1: Transmission Scheme Clarification  Fine with the transmission scheme clarification, and both proposals.  Issue 2-1-2: Scenario Clarification and Simplification  We are trying to provide another aspect for down-selecting scenarios by proposing P2 and P3. For P1, it may be dependent on operators’ deployment demands.  Issue 2-2-1: General view toward Uni-directional Deployment  We agree with observation 2.  Issue 2-2-2: View toward JT for all channels (full SFN) for Uni-directional Deployment  Fine with P1.  Issue 2-4-1: SSB index to Beam Mapping:  Option 3. There should be some flexibility regarding SSB index to beam mapping. Different scenarios may have different suitable mapping scheme.  Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any):  For number of panels per CPE, we can start with 1T1R or 1T2R per CPE. For bi-directional operation for two panels if any, P1 is ok. For P2, this has no spec impact, up to network choice.  Issue 2-4-3: Number of CPE devices per train/carriage:  If CPEs are not assumed to work jointly, then we can just consider one CPE per train for specifying requirements.  Issue 2-4-5: Tunnel Deployment Scenario  We support to include this scenario to guarantee deployment coverage and flexibility.  Issue 2-5-1: Revisit FR2 HST Deployment Parameters  At this stage we could focus on the agreed parameters.  Issue 2-6-2: Channel modelling for performance requirements:  We are fine with single-tap model for a single Tx-Rx link.  Issue 2-7-1: Numerology considered for maximum supported speed  Ok with 120k SCS for the maximum supported speed. |
| Intel | **Issue 2-1-1: Transmission Scheme Clarification**  Agree with recommended WF.  P1: We should focus only on Rel-15/16 Tx schemes  P2: In scenario with JT + distributed SSB the QCL-D assumption cannot be followed for PDSCH and there are no benefits to enable JT scheme. Besides that, we share similar views as Ericsson that JT with bidirectional deployment is not reasonable since we consider only one active panel at each time. Suggest focusing on JT only for unidirectional deployment scenario.  **Issue 2-1-2: Scenario Clarification and Simplification**  P1: As starting point we can assume one train and one side RRH location on the track. Same time further we need analyse impact of another train and another RRH location options on deployment aspects  As for one moving direction, we think it is necessary to consider both: toward and opposite. It has direct explicit impact on number of panels on UE and RRH side. For example, in unidirectional deployment there is no chance to serve UE equipped with one panel if it is moving in opposite direction to RRH panel orientation. Suggest the following: As starting point consider one train per track and one side RRH location on the track. Same time further analysis on potential impact on deployment parameters is needed with assumptions of two trains moving in different directions and non-unified location of RRH on track. Analyse deployment aspects under assumption that train can move in different directions.  P2: We have already done prioritization to scenario 2 and 4. Same time we are fine to indicate that we have two groups: one with close to railway RRH deployment and another with far from track. Also, in our understanding all of them correspond to open space deployment and we should discuss channel model for tunnel scenario separately.  P3: At current stage it is not clear why we should do such differentiation. We prefer to analyse both SCS for both prioritized scenarios to identify practical constraints for each SCS.  **Issue 2-2-1: General view toward Uni-directional Deployment**  O1: First of all, we should follow Rel-16 assumptions and do not assume that reception can be performed simultaneously from 2 Rx beams. As for limited DL and UL coverage, based on the observations from our contribution for last meeting and from other companies’ contributions for this meeting: for both Uni- and Bi-directional deployments the zone near the RRH is the most problematic area due to the need for very fast beam switching. The best option is to serve this area by the neighbouring RRH. This leads to similar coverage requirements for Uni- and Bi- directional cases  O2: CP length is not a limited factor when timing is changed considering course SSB based synchronization. Same time we agree that further analysis is needed since timing is changed dramatically.  **Issue 2-2-2: View toward JT for all channels (full SFN) for Uni-directional Deployment**  O1. We agree that there are no benefits to configure JT with several beams per RRH in unidirectional deployment. To safe energy it is better to assume DPS Tx. Same time in our analysis we show that fixed beam operation is possible in this scenario. If we need to capture this observation as common understanding, we also would like to add note that fixed beamforming is possible from link budget analysis perspective. Also, we share similar view as Ericsson that JT should be considered only for unidirectional deployment since for bidirectional UE anyway cannot simultaneously receive two PDSCH.  P1: Agree with proposal that for JT we should assume only single TCI state. Otherwise SFN Tx of PDSCH + different TCI states from each TRP refers to Rel-17 eMIMO schemes with distributed TRS Tx. Can Qualcomm clarify QCL assumptions in case of Full SFN Tx and two TCI states which corresponds to different RRHs?  **Issue 2-2-3: View toward DPS for Uni-directional Deployment**  As we see, companies have same view on required number of beams per RRH per UE: 1 or 2. There is no need to consider higher than 2 beams. Based on our analysis even 1 fixed beam at RRH and UE is enough to scenarios with relatively high Ds.  As for TCI state configuration for DPS Tx scheme, we can consider one active TCI as baseline.  **Issue 2-2-4: View toward Multi-DCI based Multi-TRP Transmission for Uni-directional Deployment**  Agree with the Observation  **Issue 2-2-5: Evaluation Parameters Selection for Uni-directional Deployment**  Agree with Proposal 1  **Issue 2-3-1: General view toward Bi-directional Deployment**  The observation seems reasonable.  **Issue 2-3-2: View toward JT for all channels (full SFN) for Bi-directional Deployment**  Agree with proposal. Based on our link budget analysis the receive power difference between two links is large and there is no benefits of PDSCH combining. It may cause only additional ICI due to different opposite Doppler frequencies.  **Issue 2-3-3: View toward DPS for Bi-directional Deployment**  O2: Agree with the observation. The best way to resolve the problem is to cover this area by neighbouring RRH.  **Issue 2-3-4: View toward Multi-DCI based Multi-TRP Transmission for Bi-directional Deployment**  We do not think that multi-DCI Tx scheme is applicable to HST FR2 due to high directivity of Tx beams. UE cannot receive both PDSCH simultaneously considering only one Rx beam at each time.  **Issue 2-3-5: Evaluation Parameters Selection for Bi-directional Deployment**  Agree with Proposal 1 with the following clarifications /modifications:   1. Consider 1 beam per panel and 2 panels per RRH. 2 analog beams per RRH in total 2. Propose also to consider RRH panel boresight pointed to the railway at the distance of Ds (projection of the neighboring RRH on the railway) to cover area near neighboring RRH   **Issue 2-4-1: SSB index to Beam Mapping**  Following assumption on having only DPS for bidirectional we do not see any reason to have shared SSB. Shared SSB could be used in JT operation  **Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any):**  Number of panels per CPE depends on unidirectional or bidirectional deployment is assumed. No need to differentiate between Tx and Rx panels.  We are ok to discuss signalling on the next stage  **Issue 2-4-3: Number of CPE devices per train/carriage**  Can consider 1 CPE per train as baseline assumption but spatial multiplexing can be further analysed  **Issue 2-4-4: Tunnel Deployment Scenario**  In FR2 we have limited signal penetration and much signal reflections, so Tunnel scenario should be considered separately from other scenarios. Different channel model (pathloss model) for the analysis should be applied  **Issue 2-5-1: Revisit FR2 HST Deployment Parameters**  We prefer to keep the scenarios, defined in the previous meeting. However, we need the operators input for the decision  **Issue 2-5-2: Revisit FR2 Beamforming Modeling**  Agree with Ericsson that these parameters are more suitable for FR2  **Issue 2-6-1: Pathloss model used for link budget evaluation**  Agree with proposal to consider RMa LoS for link budget analysis.  **Issue 2-6-2: Channel modelling for performance requirements:**  Observation seems reasonable  **Issue 2-7-1: Numerology considered for maximum supported speed**  Analysis should assume both SCS since different networks may use either 60 kHz or 120 kHz SCS. For which SCS we need to define requirements is another question and should be discussed further according to WI plan. We can expect that 60 kHz SCS has more strict limitation on max UE speed hence we can assume different requirements from RRM perspective for each SCS. In this case we prefer to analyse both SCS on max supported speed.  **Issue 2-7-2: Maximum Supported Speed from DL Perspective**  Max supported UE velocity depends on RS type that is used for frequency tracking. Potentially it can be TRS, DMRS, PTRS or combination of different types. Different implementations may use different RS types. We propose to list possible RS for DL frequency tracking and analyse pros/cons of them next meeting and also ask companies to provide feedback on typical implementations. After that we can discuss DL limitations for baseline implementations.  **Issue 2-7-3: Maximum Supported Speed from UL Perspective**  Same comment as for DL. Different companies may assume different RS for frequency tracking and hence have different limitations on max supported UE velocity. In this case we suggest listing DMRS and PTRS as possible candidates for UL frequency tracking and discuss next meeting pros/cons of them and further make conclusion on max supported UE velocity.  **Issue 2-7-4: The necessity of checking demodulation feasibility for maximum supportable speed**  Max UE velocity has direct impact on beam management as well as on RRM requirements in general. In this case we suggest starting demodulation performance evaluations as soon as possible to understand main limitation factor and speed upper-bound. Analysis from both DL and UL are required. Based on our initial study we observed that support of high order modulation (which should be prioritized since we assume only one CPE to serve all UEs inside train) might be quite challenging in UL due ICI produced by high frequency mismatch when we perform baseband frequency offset compensation. We would like to encourage other companies to take look on this issue since it can be one of the main reasons to strictly reduce max supported UE velocity.  **Issue 2-7-5: Parameters to check demodulation feasibility for maximum supportable speed**  We can merge both tables. Same time we have additional comments:  1) Both SCS should be configured. 2) 2x2 antenna configuration to check rank 2 performance 2) Since it is a study stage. we should consider all possible additional DMRS configurations even 1+1+1+1 is optional configuration.  3) PTRS can be also enabled and different Time density should be analysed. 4) MCS 13, 17 can be assumed with rank 1 or rank 2.  We should keep in mind that since there is only one CPE per train it is more natural to assume high MCS and Rank in both UL and DL directions. |
| Nokia, Nokia Shanghai Bell | **Issue 2-1-1: Transmission Scheme Clarification** We agree with **Proposal 1** that the schemes not comparable with NR Rel-15/16.  We see a small unclarity in Moderator’s definition of Joint Transmission, i.e., it is only applied to the Full SFN, but not mentioned for Multi-DCI based Multi-TRP Transmission. Is this last scheme also considered as JT?  Regarding **Proposal 2**, we still see a need to analyse and discuss further if other Rel-15/16 JT comparable schemes are relevant to the HST FR2 deployments.  **Issue 2-1-2: Scenario Clarification and Simplification** In our **Proposal 1**, we would like to establish a baseline/priority scenario for better comparability of results. However, we do not propose to preclude other scenarios if companies see a need to analyse those.  **Proposal 2**: In our opinion, we have already identified 2 priority scenarios (2 and 4) representing these groups. No further improvements are needed.  **Proposal 3**: Firstly, we think that SCS discussion, if needed, should go in connection with the maximum Doppler shift and maximum speed analysis. Secondly, our preference is to keep only 120kHz SCS. Finally, a discussion about a need for separate consideration of tunnel scenario can take place, but without a direct connection to the SCS.  **Issue 2-2-1: General view toward Uni-directional Deployment** **Observation 1** needs a clarification. Firstly, we do not agree that unidirectional setting is coverage limited, at least for the distances of identified deployment scenarios. Secondly, WID limits CPE to have only one active panel at a time. Therefore, unidirectional setting is not suffering from the large changes in Doppler shift.  **Observation 2**: We agree that when the change of RRH happens without a random access procedure, it is necessary to study further what could be the impact of a large shift in receive timing.  **Issue 2-2-2: View toward JT for all channels (full SFN) for Uni-directional Deployment** We have a similar understanding with **Observation 1**. It makes sense to consider unidirectional SFN deployment with only one beam per RRH. It can be selected as a priority option. However, with larger Dmin more beams can be still used. We would not exclude this option completely yet.  **Proposal 1:** If Full SFN scheme is discussed here, our understanding is that it can have only one TCI state by definition. Our opinion is that only this scheme (out of all other possible JT schemes) shall be considered in unidirectional setting because there is no strong need for fast beam switching or HO. CPE stays in the coverage of the previous RRM sufficiently long time.  **Issue 2-2-3: View toward DPS for Uni-directional Deployment** Similarly to the previous issue, we propose to consider DPS unidirectional setting with one beam per RRH and open beam per CPE, and one TCI state as the primary option. If any problems in system pefromance or meaningful gains from additional TCI states are identified, then alternative options can be considered as well.  **Issue 2-2-4: View toward Multi-DCI based Multi-TRP Transmission for Uni-directional Deployment** Agree this the Observation, please, see our comment on the previous issue.  **Issue 2-2-5: Evaluation Parameters Selection for Uni-directional Deployment** We agree with the **Proposal 1** as a default case. However, we do not see any benefit in analysing more than one beam per RRH here. More than one beam may be useful only for larger values of Dmin. Therefore, we would still keep another priority option with Ds=300m and Dmin = 50m in unidirectional setting but with lower priority.  **Issue 2-3-1: General view toward Bi-directional Deployment** Note, our observation is made based on the simulation setup where each RRH is mapped to one cell (L3, HO-based mobility between RRHs). However, we expect that a similar observation can be made for SFN type of scenario with beam switching based mobility.  **Issue 2-3-2: View toward JT for all channels (full SFN) for Bi-directional Deployment** In our opinion, firstly, it is necessary to decide if CPE with only one panel can be used in such deployment or not, e.g., when one panel is installed horizontally and can receive signals from two RRH at the same time. If only two panels per CPE oriented into opposite directions are considered (our primary option), then we agree with **Proposal 1**.  **Issue 2-3-3: View toward DPS for Bi-directional Deployment** Agree to keep bidirectional deployment with DPS scheme as a feasible option for further analysis in HST FR2 WI.  **Issue 2-3-4: View toward Multi-DCI based Multi-TRP Transmission for Bi-directional Deployment** Unless it is shown to be necessary, we do not see a strong need to consider more than 2 TCI states. Agree on Observation 1.  **Issue 2-3-5: Evaluation Parameters Selection for Bi-directional Deployment** From the analysis presented in our contribution, it follows that more than 2 beams per RRH can still be beneficial to improve coverage next to the RRH site. On the other hand, deployments with one beam per RRH can still be a feasible deployment and a reference for other deployments. Hence, we would preferer to keep our proposal with 1,2,4 beams per RRH. Otherwise, parameters look fine.  **Issue 2-4-1: SSB index to Beam Mapping** We agree that for the evaluation purpose Option 2 can be selected as a baseline scenario. However, we are not sure, that in practice it is possible to enforce only such type of deployment. Therefore, it is necessary to study further, if Option 1 configuration can bring any potential problems.  **Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any)** Regarding **Proposal 1 on the number of panels per CPE**, we are wondering what is a point in considering only 1 Tx panel if there are anyways 2 Rx panels, when the network is operated in a TDD setting. Regarding the bidirectional capability flag (**Proposal 1**) and its utilization (**Proposal 2**), we think that further clarification and analysis is needed. For example, can we always assume that only one type of CPE is present in the network?  **Issue 2-4-3: Number of CPE devices per train/carriage:** We still propose to consider the scenario with one CPE per train as a baseline. However, we agree that the possible additional interference if more than one CPE per train is used shall be studied.  **Issue 2-4-5: Tunnel Deployment Scenario** In our opinion, we need to focus on the deployment scenarios with validated practical usability. If a need for the tunnel deployment scenario is confirmed, we will be eager to take in into consideration.  **Issue 2-5-1: Revisit FR2 HST Deployment Parameters Observation 1**: Following our initial simulations results reported in [R4-2102093] deployment with Ds=300m looks to be feasible. However, the study of the scenarios shall still continue.  Regarding **Observation 2 and Proposal 1**, we think that the conclusions about the priority of these scenarios shall be made based on the operators’ input. Additionally, we do not expect that changing Dmin from 10 t0 15 meters will have any meaningful impact on the system performance.  **Issue 2-5-2: Revisit FR2 Beamforming Modeling** We agree with Proposal 1. It is preferable to have physically correct antenna model.  **Issue 2-6-1: Pathloss model used for link budget evaluation** In our contribution [R4-2016387] for the previous RAN4 97e meeting we raised some concerns about the validity of RMa model for the 30GHz frequency band. However, if only LoS component of the model is used there is a minor difference between UMa and RMa models. Thus, we can compromise on Proposal.  **Issue 2-6-2: Channel modelling for performance requirements** It looks like our former agreement is aligned with the observation. The reason why the multi-tap model in DL direction was added because, in our understanding, bidirectional SFN scenario with one CPE panel is not completely excluded from the analysis. We propose to keep all existing options from the previous agreement until we have agreements on deployment scenarios.  **Issue 2-7-1: Numerology considered for maximum supported speed** Agree with Proposal 1.  **Issues 2-7-4, 2-7-3 and 2-7-4: Maximum Supported Speed** It is obvious that the UL is more challenging from demodulation point of view. However, based on our preliminary analysis that coincides with other company’s’ conclusions, the maximum speed of 350 kmph can be supported even in UL but with a significant number of additional refence symbols (either DM-RS or PT-RS). Therefore, it is necessary to demonstrate the relation between possible reference symbols patterns, introduced overhead, and maximum supported speed. Even though we have not observed any mobility problems in our first system-level simulations, additional analysis is still need from the RRM point of as well. To conclude, more study is still needed to agree on the maximum supported speed.  We also have **a question to Intel** regarding Performance evaluation results (Section 2.2.3.1 in R4-2101267): we would expect that the reception will be corrupted starting with certain speed regardless of the MCS index due to impossibility to evaluate Doppler shift from reference symbols. Do you have an explanation why there is dependency on the MCS in your results?  **Issue 2-7-5: Parameters to check demodulation feasibility for maximum supportable speed** It is good to have link level simulations parameters used by other companies as a reference. However, in our view, it is early to make agreements about demodulation performance configurations at this meeting yet. The discussion should take place at the next meeting when Demodulation pefromance part discussion starts. |
| Huawei, HiSilicon | **Issue 2-1-1: Transmission Scheme Clarification**  We are OK with Proposal-1 and Proposal-2.  **Issue 2-1-2: Scenario Clarification and Simplification**  RRHs are located at both sides of the track should be more typical for the real network deployment;  Only 120kHz SCS is enough considering 120kHz SCS is the typical use cases for FR2 for real deployment and higher Doppler shift supporting for HST.  Scenario {Ds = 700m, Dmin=150m} should also be considered.  **Issue 2-2-1: General view toward Uni-directional Deployment**  From our view, to achieve the same UL and DL coverage as bi-directional deployment, almost twice number of RRHs compared to bi-directional, this will cause serious cost for FR2 HST deployment, this factor should be considered for FR2 HST when RAN4 discuss the candidate scenarios.  **Issue 2-2-2: View toward JT for all channels (full SFN) for Uni-directional Deployment**  From our point of view, DPS is suitable for uni-directional, we are wondering how smaller Dmin can be used to achieve the reception from several TRPs by using JT for uni-directional with one beam directional for each TRP.  **Issue 2-2-3: View toward DPS for Uni-directional Deployment**  Different companies have different observations based on evaluations on different Scenarios and assumptions. Further evaluations and discussions should be based on the same assumptions to derive the common observations. At least 2 active TCI states should be considered.  **Issue 2-2-4: View toward Multi-DCI based Multi-TRP Transmission for Uni-directional Deployment**  We share the similar observation. We do not think that MTRP is suitable for uni-directional deployment with one beam direction. MTRP is designed for transmission from different TRPs with different directions and UE can receive the data transmitted from both TRPs at the same time.  **Issue 2-2-5: Evaluation Parameters Selection for Uni-directional Deployment**  We still have concern on the Dmin=10m smaller than RRH height=15m for the safety considering impact from the possible hurricane in reality, it should be double checked.  **Issue 2-3-1: General view toward Bi-directional Deployment**  The real time-of-stay of cell depends on the Ds and number of TRPs connected to one BBU, we cannot conclude that bi-directional cause more handovers than uni-directional. Same assumptions should be assumed for the comparison.  **Issue 2-3-2: View toward JT for all channels (full SFN) for Bi-directional Deployment**  Considering the sensitive ICI for FR2 and multiple paths delay spread, and evaluations conducted for DPS and HST-SFN for R16 FR1 HST, DPS is a good candidate to consider.  **Issue 2-3-3: View toward DPS for Bi-directional Deployment**  From Observation 2/3, further evaluations are needed to reach common understanding based on the same assumptions.  **Issue 2-3-4: View toward Multi-DCI based Multi-TRP Transmission for Bi-directional Deployment**  Like we commented on Issue 2-3-2, we do not think the m-DCI based m-TRP transmission scheme is suitable for FR2 HST considering the sensitive ICI issues and UE reception capability with only 1 active Rx panel.  **Issue 2-3-5: Evaluation Parameters Selection for Bi-directional Deployment**  Scenario {Ds = 700m, Dmin=150m} should also be considered. Also same concerns on Dmin=10m safety in Scenario-2.  **Issue 2-4-1: SSB index to Beam Mapping:**  Considering the DPS scenario, the SSB index to Beam mapping can be as following:    All RRHs connected to one BBU use the same set of SSB indexes.  **Issue 2-4-2: Number of panels per CPE and Bi-directional Operation for Two Panels (if any):**  Number of CPE per train depends on the real deployment to ensure the capability and avoid the interference. From performance requirements definition of view, we prefer not consider these and base on 1 CPE per train.  We do not think that it is necessary to signal UE capability to support bi-directional or not, we think that operator and train companies will co-operate with each other during the deployment to ensure the matching of CPE panel direction and network beam direction.  **Issue 2-4-3: Number of CPE devices per train/carriage:**  Number of CPE per train depends on the real deployment to ensure the capability and avoid the interference. From performance requirements definition of view, we prefer not consider these and base on 1 CPE per train.  **Issue 2-4-5: Tunnel Deployment Scenario**  We did not observe the feasibility to use Tunnel deployment scenario for FR2 considering the reflection and refraction in the tunnel environment and serious attenuation.  **Issue 2-5-1: Revisit FR2 HST Deployment Parameters**  Down selection for those listed candidate scenarios in last meeting should be made based on companies’ evaluations.  **Issue 2-5-2: Revisit FR2 Beamforming Modeling**  Further investigation for the antenna parameters is needed.  **Issue 2-6-1: Pathloss model used for link budget evaluation**  We are ok for the proposal.  **Issue 2-6-2: Channel modelling for performance requirements:**  Single tap is OK for single TX-RX, FFS for others.  **Issue 2-7-2: Maximum Supported Speed from DL Perspective**  Based on the WID, the maximum supported speed and Doppler shift should based on the Rel-15/16 NR design limitations for all UL/DL physical channels, no any advanced processing should be considered for evaluations and performance requirements definition if agreed; the DM-RS configuration 1+1+1 is mandatory and should be used as the basic assumptions.  **Issue 2-7-3: Maximum Supported Speed from UL Perspective**  Same comments on DL. The limitation for UL and DL should be considered together to decide the final maximum supported speed with basic Rel-15/16 NR design limitations for all UL/DL physical channels.  **Issue 2-7-4: The necessity of checking demodulation feasibility for maximum supportable speed**  Same comments on Issue 2-7-2 and 2-7-3.  **Issue 2-7-5: Parameters to check demodulation feasibility for maximum supportable speed**  The evaluations on the channel model to decide the specific Ds, Dmin, antenna parameters and etc., have higher priority. The maximum supported velocity can be based on certain assumptions of the carrier frequency, DM-RS configurations, the basic Doppler shift estimation and etc., no need to derive it by demodulation feasibility evaluations. |

### CRs/TPs comments collection

*N/A.*

## 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:* |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
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### CRs/TPs

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

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| **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)

## Summary on 2nd round (if applicable)

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

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

# Topic #3: UE RF Requirements for FR2 HST

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2100918 | Samsung | Observation-1: The to-be-determined FR2 HST deployment scenario will impact the UE RF core requirement to be specified by RAN4.  Proposal-1: For FR2 HST UE (roof-mounted UE type), RAN4 assume UE shall meeting the minimum peak EIRP requirement and spherical coverage requirement with its autonomously chosen UL beams and without uplink beam sweeping. |
| R4-2102561 | Nokia, Nokia Shanghai Bell | Observation 1: It is preferred to reuse the existing PC4 requirement as much as possible.  Observation 2: The spherical coverage could be revisited considering the antenna pattern of the roof-top mounted antennas and HST network deployment.  Observation 3: The better beam correspondence requirement than PC3 is required for FR2 HST so that the uplink beam sweeping should not be required. |
| R4-2102679 | Ericsson | Proposal 1: Discuss the UE requirement for spherical coverage and limit it if needed.  Proposal 2: Consider increasing maximum output power for train mounted HST FR2 UEs.  Observation 1: If the two proposals in this paper are agreed upon it might lead to the need for defining a new PC class for HST FR2 UEs. |

## 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: UE RF requirements for FR2 HST

*Sub-topic description:*

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

**Issue 3-1-1: Baseline power class and UE RF requirement for FR2 HST**

* Proposals and observations:
  + Nokia’s observation:
    - It is preferred to reuse the existing PC4 requirement as much as possible.
    - The spherical coverage could be revisited considering the antenna pattern of the roof-top mounted antennas and HST network deployment.
  + Ericsson’s observation and proposal:
    - Discuss the UE requirement for spherical coverage and limit it if needed.
    - Consider increasing maximum output power for train mounted HST FR2 UEs.
    - If the two proposals in this paper are agreed upon it might lead to the need for defining a new PC class for HST FR2 UEs.
* Recommended WF
  + Companies’ views are collected in 1st round discussion.

**Issue 3-1-2: Beam Correspondence:**

* [Moderator] In WID, RAN4 is tasked to study whether or not beam correspondence requirement is needed for FR2 HST.
* Proposals:
  + Proposal-1 (Samsung/Nokia): For FR2 HST UE (roof-mounted UE type), RAN4 assume UE shall meeting the minimum peak EIRP requirement and spherical coverage requirement with its autonomously chosen UL beams and without uplink beam sweeping.
* Recommended WF
  + Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

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| **Company** | **Comments** |
| Samsung | Sub topic 3-1: UE RF requirements for FR2 HST  Issue 3-1-1: Baseline power class and UE RF requirement for FR2 HST  - Generally speaking, we agree to reuse PC4 as much as possible, but the spherical coverage needs revisit at least. For whether or not PC4 is feasible by train-roof-mounted UE type, we need more time to check from RF implementation perspective.  Issue 3-1-2: Beam Correspondence:  - As proponent of P1, we suggest RAN4 to preclude bit-0 UE in the discussion of FR2 HST, i.e., all UE should be BC bit-1 UE. |
| Ericsson | **Issue 3-1-2: Beam Correspondence:**  We do need beam correspondence (bit-1 variant) but we may not necessarily need spherical coverage |
| QC | **Issue 3-1-1:** The feasibility of applying maximum output power for PC4 to FR2 HST CPE device has to be revisited. The current PC4 requirement is even higher than PC5, which is considered a 16e device, and already employs power limiting to stay under the TRP limit of 23dBm. The significance is that EIRP increase from PC5 levels is very expensive because of TRP limit (it only grows at 10 log N)..  **Issue 3-1-2:** We support proposal 1 |
| Huawei | Issue 3-1-1: UE RF requirement is highly related to deployment discussion outcome. Now, both one panel and 2 panels(for bidirectional) assumption are raised in Topic #2. It should be note that currently TS 38.101-2 power class definition is based on “only one panel active at a time”.  Min peak EIRP need to consider the discussion in PC5 with the same TRP upper limitation=23dBm. Based on our evaluation, min peak EIRP=32dBm is hard to exceed even more antenna elements number is assumed.  Issue 3-1-2: Beam correspondence requirement need to be revisited, since the transmission scheme is still under discussion(), the current side condition in TS 38.101-2 may not applicable to FR2 HST(e.g. one AOA). |
| ZTE | **Issue 3-1-2: Beam Correspondence:**  bit-1 UE should be supported, whether excluding bit-0 UE needs to be considered with transmission scheme. |
| Intel | **Issue 3-1-1: Baseline power class and UE RF req**  Overall, we are ok to discuss and potentially reuse as much of PC4 as possible, but we need to further consider and discuss power class aspects for this use case (spherical coverage, min peak EIRP). Ideally, we want to avoid having to define a new FR2 power class, thus we should *also* consider whether other FR2 power classes can work for HST.  **Issue 3-1-2: Beam correspondence**  If we look at FR2 power classes, BC has only been defined for PC3 so far, and it is under discussion for other power classes. For HST, this needs to be further discussed. |

### CRs/TPs comments collection

*N/A.*

## 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:* |

*Recommendations on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
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### CRs/TPs

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

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| **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)

## Summary on 2nd round (if applicable)

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

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