**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) | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

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

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

*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*

|  |  |
| --- | --- |
| **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

|  |  |  |
| --- | --- | --- |
| **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 310 for CSI-RS resource 2 and 4 |
| CSI-RS offset | Slots | 4 for CSI-RS resource 1 and 25 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: 1Option 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 timeProposal 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 CPEObservation 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 = 10mScenario-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 degreeScenario-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 changeObservation 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 panelsProposal 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 signalsb. 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 scenariosObservation 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 = 10mScenario-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 degreeScenario-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 310 for CSI-RS resource 2 and 4 |
| CSI-RS offset | Slots | 4 for CSI-RS resource 1 and 25 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: 1Option 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 DeploymentIssue 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 DeploymentIssue 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 StudyIssue 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 RevisitIssue 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 ModelingIssue 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 SpeedIssue 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.  |

### 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.*

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

*Suggestion 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*

|  |  |
| --- | --- |
| **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 #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

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Samsung | Sub topic 3-1: UE RF requirements for FR2 HSTIssue 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.  |

### 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.*

|  |  |
| --- | --- |
|  | **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*

|  |  |
| --- | --- |
| **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”* |