**3GPP TSG-RAN WG4 Meeting # 97-e R4-20xxxxx**

**Electronic Meeting, 2nd – 13th Nov., 2020**

**Agenda item:** 12.7

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for [97e][138] 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], with the following objectives included for core part:

|  |
| --- |
| * Investigate and specify the following scenarios
	+ 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
	+ Stage 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
	+ Stage 2: Specify enhanced RRM requirements based on outcome of Stage 1
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*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: Initial discussion on the general aspects, work plan, 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, as the basis for future discussion.

# Topic #1: General and Work Plan

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2014846 | Samsung, Nokia, Nokia Shanghai Bell | Work plan for NR support for high speed train scenario in FR2 |
| R4-2015880 | Nokia, Nokia Shanghai Bell | TR skeleton for NR support for high speed train scenario in FR2 |

## Open issues summary

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

### Sub-topic 1-1: Work Plan

*Sub-topic description:*

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

**Issue 1-1-1: Work Plan for Core Part**

* Core part plan from rapporteur for comment collection (R4-2014846):
	+ RAN4#97-e: Nov. 2nd – 13th, 2020
		- Agree overall work plan for core and performance part;
		- Discuss FR2 HST deployment scenario and study the channel model for FR2 HST;
		- Discuss and identify potential impact on RF requirements.
	+ RAN4#98-e: Jan. 25th – Feb. 05th, 2021
		- FR2 HST deployment scenario and channel modeling:
			* Identify the required FR2 HST deployment scenarios from operators;
			* Further discuss the detailed FR2 HST deployment parameters and channel modeling;
			* Discuss the maximum supported velocity for FR2 HST.
		- UE RF:
			* Initial discussion on UE RF requirements impact due to FR2 HST scenario, i.e., UE for train roof-mounted high-power devices.
		- RRM (core part):
			* Initial discussion on RRM requirements impact and possible enhancement for FR2 HST scenario.
	+ RAN4#98-bis-e: Apr. 12th – 20th, 2021
		- FR2 HST deployment scenario and channel modeling:
			* Conclude the targeted baseline FR2 HST deployment scenario;
			* Conclude the detailed FR2 HST deployment parameters;
			* Conclude the channel model for FR2 HST;
			* Conclude the maximum supported velocity for FR2 HST.
		- UE RF:
			* Further discussion on UE RF requirement impact due to FR2 HST scenario;
			* Specify the UE RF core requirements on the basis of power class 4 if identified.
		- RRM (core part):
			* Further discussion on RRM requirements impact for FR2 HST scenario:
			* Identify requirement impact for Idle/Inactive mode cell reselection;
			* Identify requirement impact for Connected mode, i.e., handover delay, measurement, and beam management requirement;
			* Identify requirement impact for other RRM requirement, if any.
	+ RAN4#99-e: May 19th – 27th, 2021
		- FR2 HST deployment scenario and channel modeling:
			* Conclude the remaining issues for FR2 HST deployment and channel modeling,
			* Complete the corresponding TR drafting work for FR2 HST deployment scenario and channel modeling.
		- UE RF:
			* Further discussion on the UE RF core requirement on the basis of power class 4 if identified;
		- RRM (core part):
			* Further discussion on RRM requirements and bring draft CRs for identified RRM core requirements:
			* Requirement for Idle/Inactive mode cell reselection, if identified
			* Requirement for Connected mode, i.e., handover delay, measurement, and beam management requirement, if identified.
			* Other RRM requirement, if any.
	+ RAN4#100: Aug. 23th – 27th, 2021
		- UE RF:
			* Conclude the UE RF core requirement on the basis of power class 4 if identified and bring CRs to finalize UE RF requirement impact;
			* Complete the corresponding TR drafting work for UE RF core requirement impact due to FR2 HST.
		- RRM (core part):
			* Resolve remaining open issues for RRM requirements and bring CRs to finalize corresponding RRM core requirements;
			* Complete the corresponding TR drafting work for RRM core requirement impact due to FR2 HST.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-1-2: Work Plan for Performance Part**

* Performance part plan from rapporteur for comment collection (R4-2014846):
	+ RAN4#98-bis-e: Apr. 12th – 20th, 2021
		- RRM (performance part):
			* Discussion on RRM performance requirement of measurement accuracy if identified;
		- Demodulation:
			* Discuss and identify potential impact on BS/UE performance requirements;
			* Discuss channel models to be adopted for UE/BS demodulation test cases;
			* Agree initial simulation assumptions for BS, UE demodulation test cases.
	+ RAN4#99-e: May 19th – 27th, 2021
		- RRM (performance part):
			* Further discussion on RRM performance requirement of measurement accuracy.
		- Demodulation:
			* Agree performance test cases scope and TR drafting for corresponding part;
			* Bring CRs for channel models for UE/BS demodulation;
			* Bring initial evaluation results and further update simulation assumption for detailed test set-up.
	+ RAN4#100: Aug. 23th – 27th, 2021
		- RRM (performance part):
			* Conclude RRM performance requirement of measurement accuracy and bring CR to complete the corresponding measurement accuracy requirement.
			* Discussion on the scope of RRM test cases related to new core requirement, and agree the work split for RRM test cases.
		- Demodulation:
			* Further discussion on the performance evaluation and result alignment on UE and BS demodulation;
			* If necessary, further update simulation assumption for detailed test set-up.
	+ RAN4#100-bis: Oct. 11th – 15th, 2021
		- RRM (performance part):
			* Complete remaining issues (if any) for RRM performance requirement of measurement accuracy.
			* Discussion on the drafted CR for RRM test cases for the impacted RRM requirements.
		- Demodulation:
			* Bring IM results and further result alignment for agreed BS and UE demodulation test cases.
	+ RAN4#101: Nov. 15th – 19th, 2021
		- RRM (performance part):
			* Bring CRs for RRM test cases for the impacted RRM requirements.
		- Demodulation:
			* Further result alignment on IM results for agreed BS and UE demodulation test cases.
			* Bring CRs for demodulation performance requirements.
	+ RAN4#102: Feb. TBD, 2022
		- RRM (performance part):
			* Complete CRs for RRM test cases for the impacted RRM requirements.
			* Complete remaining issues (if any) for RRM test cases for the impacted RRM requirements.
		- Demodulation:
			* Complete CRs for demodulation performance requirements.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1: Sub topic 1-2:….Others: |
| Verizon | **Issue 1-1-1 and Issue 1-1-2:****We support both work plans!** |
| QC | Issue 1-1-1:In our opinion, UE RF impact is not clear before deployment scenario is agreed.  |

### CRs/TPs comments collection

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2015880 (TR skeleton for NR support for high speed train scenario in FR2) | Company A |
| Company B |
| Ericsson: Editorial, Clause 6 appears twice.Is the placeholder for “Release independent aspects” in the right place? I.e. within the RRM clause. Could also consider leaving that out from the TR for nowFor RRM (as well as for Demod even if it’s not included in the TR draft), our view is that capturing FR2 HST requirements in the TR will create unnecessary overhead and maintenance issues. The main purpose of the TR should be to capture deployment related assumptions used to derive the requirements and other aspects such as asasumed UE speed. We could also capture candidate solutions for RRM as was done in the TR for LTE HST in release 14, but as for RRM requirements these should be captured directly to TS38.133 as necessary. |
|  |

## 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** |
| R4-2014564 | Intel Corporation | Proposal #1: Consider 4 RRHs per one BBU for FR2 HST deployments.Proposal #2: Consider both 60 kHz and 120 kHz SCSs for FR2 HST deployments.Observation #1: Different propagation models impose different restrictions on deployment size• RMa NLOS: sufficient link budget to guarantee support of 64QAM + Rank 2 can be achieved only in deployments with max propagation distances less than 150m for both PC4 and PC3 UEs.• RMa LOS: sufficient link budget to guarantee support of 64QAM + Rank 2 can be achieved in deployments with max propagation distances less than 650m and less than 500m for PC4 and PC3 UEs respectively.Observation #2: In HST FR2 scenario with LOS propagation model• One panel per RRH configuration: o UE PC4 cannot provide operation with 64QAM+Rank2 with deployment option 1 (Ds=700m, Dmin=150m)o UE PC3 cannot provide operation with 64QAM+Rank2 with deployment option 1 (Ds=700m, Dmin=150m) and deployment option 3 (Ds=580m, Dmin=5m)• Two panel per RRH configuration does not impose restrictions on 64QAM+Rank2 operation for all considered deploymentsObservation #3: Performance degradation in SFN Tx mode is observed when RX timing for signals from the farthest RRHs exceeds the CP length.Observation #4: Performance degradation might be expected for HST FR2 deployment Option 1(Ds = 700m, Dmin = 150m) and Option 3 (Ds = 580m, Dmin = 5m) with SFN Tx mode since receive timing difference even between two nearest RRHs is much higher than CP length.Observation #5: Performance degradation will not be observed in HST FR2 DPS Tx mode due to high receive timing difference between RRHs.Observation #6: Benefits of using SFN Tx mode for FR2 are not very clear and should be analyzed.Proposal #3: Consider both SFN and DPS Tx modes for further analysis of appropriate Tx scheme for FR2 deployments. For SFN mode link-level and system-level studies are required to prove applicability of such Tx mode for FR2.Proposal #4: For SFN Tx mode consider deployments with only small inter-RRH distance (less than 300m)Proposal #5: Define number of panels per RRH as one of the following:Option 1: one panel per RRH pointed to the same direction for all RRHs Option 2: two panels per RRH pointed to the opposite directions Proposal #6: Define number of beams per panel as one of the following:Option 1: one beamOption 2: two beamsProposal #7: Define the SSB to beam mapping as one of the following:Option 1: separate SSBs per each beamOption 2: shared SSBs for beams from different panelsProposal #8: Define RRH panel boresight direction as one of the following:Option 1: panel boresight pointed to the railway in the middle point between 2 RRHs Option 2: panel boresight pointed to the railway at the distance of Ds (projection of the neighboring RRH on the railway)Proposal #9: Define the number of panels per CPE:Option 1: one panelOption 2: two panels pointed to the opposite directionsProposal #10: Define the number of CPE devices as one of the followingOption 1: one CPE per trainOption 2: one CPE per carriage |
| R4-2014632 | Qualcomm | Proposal 1: Evaluate the feasibility of a deployment based the above beam dwelling time and measurement period framework. |
| R4-2014834 | Verizon, Samsung | In table below, some of deployment parameters are listed for study of multi-RRH. We would require RAN4 to consider them in this work item. Table 1: RRH parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **RRH parameters** | **Power Class** | **SCS****(kHz)** |
| **Dmin (meter)** | **Ds (meter)** | **DRRH\_h (meter)** | **DUE\_h (meter)** | **Numbers of RRH per cell** |
| 1 | 10 | 800 | 10-20 | 5 | 3 | PC4 | 120 |
| 2 | 10 | 700 | 10-20 | 5 | 3 | PC4 | 120 |
| 3 | 10 | 600 | 10-20 | 5 | 4 | PC4 | 120 |
| 4 | 10 | 500 | 10-20 | 5 | 4 | PC4 | 120 |

Other deployment parameters will be considered in the study,* Initial speed: 300km/h
* RRHs Distribution: Equally distributed along the railway track
* Dmin for multi tracks: 20, 30 and 50 meters (along a main rail line)
 |
| R4-2014847 | Samsung | Observation 1: The parameters for FR2 HST deployment scenario should be identified based on operators and other interested companies’ input as below table:

|  |  |  |
| --- | --- | --- |
|  | Attributes | Values or Assumptions |
| Already Approved in WID [1] | Operation mode | NR SA single carrier scenario in FR2 |
| UE type | Train roof-mounted high-power devices |
| Applicable frequency bands | 28GHz band (n261, n257 and n258) |
| Detailed Parameters | Distance btw. RRH and railway track, Dmin | Dmin (meter) |
| Distance between adj. RRH, Ds | Ds (meter)  |
| Cell ISD | NRRH x Ds (meter) |
| RRH height (refer to train track) | DRRH\_height (meter) |
| UE height (top of train roof) | DUE\_height (meter) |

Proposal-1: Based on assumed deployment scenario, the analog beam coverage for multi-RRHs deployment should be designed to consider the tradeoff between throughput performance and mobility performance. Proposal-2: RAN4 should identify the baseline beam management design for multi-RRHs deployment in FR2 HST scenario, which will be used as the baseline scheme for UE RF, RRM and Demodulation analysis. Obervation-2: Analog beamforming design at train-roof-mounted UE for FR2 HST should be examined to guarantee the mobility performance in FR2 HST scenario.  |
| R4-2015614 | Huawei, HiSilicon | Proposal 1: Comprehensive link budget evaluations are needed to decide the detailed parameters of the number of RRHs per cell, the number of SSB, Ds and Dmin valuesProposal 2: Bi-directional SFN channel model should be considered for FR2 HSTObservation 1: for UL DM-RS 1+1+1: consider both UL and DL together and the UL limitation: the supported max velocity = 252km/h with DL fd = 7kHz and UL fd = 14kH with assumption of no positive to negative Doppler jumpObservation 2: for UL DM-RS 1+1+1+1: consider both UL and DL together and the UL limitation: v = 335km/h with DL fd = 9.3kHz and UL fd = 18.7kH with assumption of no positive to negative Doppler jumpObservation 3: No limitation for PRACH to support 350km/h velocity with carrier frequency 30GHz, i.e. max Doppler shift 9.7kHz for FR2 HST. |
| R4-2015860 | Ericsson | Proposal 1: Assume table 3 parameters (corresponding to 0.5 lambda spacing) for both BS and UE.Proposal 2: Assume UE height of e.g. 5m rather than 1.5mProposal 3: Clarify whether outdoors the BS is positioned at trackside or further away similar to FR1Proposal 4: Clarify whether coverage is provided in tunnels and if so, the assumed deployment. |
| R4-2015859(Moved from AI 12.7.1) | Ericsson | Proposal 1: Assume that the UE is a train mounted device.Proposal 2: Assume that the UE has at least panels pointing in the forwards and reverse directions. Discuss whether there is any need to consider further panels.Proposal 3: Discuss and agree spherical coverage needs for the train mounted UEProposal 4: Discuss and agree whether a limited set of beams can be assumed. |
| R4-2016387 | Nokia, Nokia Shanghai Bell | Observation 1: Unidirectional SFN deployment is a more reliable solution. It is more challenging for a UE to track the sudden Doppler frequency shift from negative to positive in bidirectional SFN deployments. Robustness can be enhanced by using multiple TCI states for the signals belonging to the same cell.Proposal 1: RAN4 to evaluate both unidirectional and bidirectional SFN deployments. Consider robustness enhancements in bidirectional SFN.Observation 2: Even for relatively mmWave narrow beams, it makes sense to consider multi-SSB deployments only when the RRH sites are more than 50 meters away from the railway track.Proposal 2: When RRH sites are 5-10 meters away from the railway track, it is sufficient consider only 1 SSB per RRH.Observation 3: It is necessary to consider minimum UE capabilities to identify, measure, and report new cells while deciding about inter RRH site distance and the number of SFN RRHs per BBU.Observation 4: There are few essential HST deployment parameters for which several values are potentially possible, e.g., inter RRH site distance, RRH and UE antenna height and orientation, etc.Proposal 3: RAN4 to evaluate two typical scenarios with longer (500-600m) and shorter(200-300m) inter RRH site distance.Observation 5: The distance between consecutive DM-RS symbols shall not be above 3 to support 350kmph train speed. Hence, at least 3 DM-RS symbols per slot should be used. 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 4: RAN4 to evaluate two maximum train speeds: 260 and 350 kmph.Proposal 5: RAN4 to consider using a single-tap per RRH channel model for performance requirements in UL direction and both single- and multi-tap models in DL direction.Proposal 6: Adopt UMa LoS model from 3GPP TR 38.901 as a baseline for system-level studies of HST in FR2. |

## Open issues summary

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

### Sub-topic 2-1: FR2 HST Deployment Scenario

*Sub-topic description:*

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

* [Moderator] As indicated in the WID, only train roof-mounted FR2 high-power devices with single panel operation on 28GHz NR SA single carrier with multiple RRHs deployed is considered, while there are still detailed parameters to be investigated and determined, which is essential for the following evaluation.
* [Moderator] Based on the input from companies, at least the following parameters are discussed (other than the ones already approved in WID):

|  |  |  |
| --- | --- | --- |
|  | Attributes | Values or Assumptions |
| Already Approved in WID | Operation mode | NR SA single carrier scenario in FR2 |
| UE type | Train roof-mounted high-power devices |
| Applicable frequency bands | 28GHz band (n261, n257 and n258) |
| Parameters | Distance btw. RRH and railway track, Dmin | Dmin (meter) |
| Distance between adj. RRH, Ds | Ds (meter)  |
| Cell ISD | NRRH x Ds (meter) |
| RRH height (refer to train track) | DRRH\_height (meter) |
| UE height (top of train roof) | DUE\_height (meter) |

The group can discuss the reasonable options or value range for the parameters, which shall be used for following feasibility discussion.

**Issue 2-1-1: RRH and UE deployment parameters (**Dmin**,** Ds**,** DRRH\_height, **and** DUE\_height**) for evaluation:**

* Proposals (may focus on different aspects):
	+ Proposal-1 (Verizon, Samsung): Four scenarios proposed:

|  |  |
| --- | --- |
| **Scenario** | **RRH and UE parameters** |
| **Dmin (meter)** | **Ds (meter)** | **DRRH\_height (meter)** | **DUE\_height (meter)** | **Numbers of RRH per cell** |
| 1 | 10 | 800 | 10-20 | 5 | 3 |
| 2 | 10 | 700 | 10-20 | 5 | 3 |
| 3 | 10 | 600 | 10-20 | 5 | 4 |
| 4 | 10 | 500 | 10-20 | 5 | 4 |

* + - Dmin for multi tracks: 20, 30 and 50 meters (along a main rail line)
	+ Proposal 2 (Intel): Following parameters used for link budget analysis:
		- RRH height: DRRH\_height = 20m
		- UE height: DUE\_height = 5m;
		- Following options from Rel-17 NR feMIMO:
			* Option 1: Ds=700m, Dmin=150m
			* Option 2: Ds=200-300m, Dmin=30-50m
				+ Option 2a: Ds=200m, Dmin = 30m
				+ Option 2b: Ds=300m, Dmin = 50m
			* Option 3: Ds=580m, Dmin=5m
	+ Proposal 3 (Ericsson): Assume UE height of e.g. 5m rather than 1.5m.
	+ Proposal 4 (Nokia): Two typical scenarios with longer (500-600m) and shorter (200-300m) Ds.
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-2: Unidirectional SFN and Bidirectional SFN:**

* Proposals:
	+ Option-1: Unidirectional SFN, i.e., one panel per RRH pointed to the same direction for all RRHs (below figure from [R4-2016387])



* + Option-2: Bidirectional SFN with one panel per RRH, i.e., signals to opposite directions along tracks (below figures from [R4-2016387] for two examples, 2 RRHs per BBU and 6 RRHs per BBU, and one panel per RRH).





* + Option 3: Bidirectional SFN with two-panel per RRH (illustrated as Figure 2-1b from R4-2014564, copied as below)
		- [Moderator] If same-BBU-connected RRHs can form different TCIs by different RRHs in Option-2, Option 3 could be the same as Option-2.



* [Moderator] The group may need to further clarify the meanings of SFN in FR2:
	+ Interpretation-1: All RRHs under one BBU transmit the same signal.
		- Selected RRH(s) for TX, depending on DPS Tx mode is used or not.
	+ Interpretation-2: All RRHs under one BBU in the same cell ID, but for different TCI.
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-3: Number of RRH per BBU:**

* Proposals:
	+ Option-1: 3 RRHs per BBU, for unidirectional SFN
	+ Option-2: 4 RRHs per BBU, for unidirectional SFN
	+ Option-3: 2 RRHs per BBU, for bidirectional SFN with one panel per RRH
	+ Option-4: 6 RRHs per BBU, for bidirectional SFN with one panel per RRH

…

* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-4: Number of Analog Beams per panel in RRH:**

* Proposals:
	+ Option-1: one analog beam per panel in RRH
	+ Option-2: two analog beams per panel in RRH
	+ Option-3: four analog beams per panel in RRH
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-5: SSB index to Beam Mapping:**

* Proposals:
	+ For one panel per RRH (either unidirectional or bidirectional SFN):
		- 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.
		- 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.
	+ Bidirectional SFN with two-panel per RRH:
		- Option-1: separate SSBs per each beam
		- Option-2: shared SSBs for beams from different panels.
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-6: RRH antenna array orientation:**

* Proposals:
	+ Option 1: RRH panel boresight pointed to the railway in the middle point between 2 RRHs
	+ Option 2: RRH panel boresight pointed to the railway at the distance of Ds (projection of the neighboring RRH on the railway)
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-7: Number of panels per CPE:**

* Proposals:
	+ Option 1: one panel
	+ Option 2: two panels pointed to the opposite directions
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-8: Number of CPE devices:**

* Proposals:
	+ Option 1: one CPE per train
	+ Option 2: one CPE per carriage
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-9: Subcarrier Spacing**

* [Moderator] For subcarrier spacing, it could be related to Doppler frequency feasibility discussion:
	+ Option-1: SCS = 120kHz
	+ Option-2: Consider both SCS = 120kHz and 60kHz.
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion and way forward is drafted with selected scenarios as assumptions for future evaluation.

**Issue 2-1-10: Tunnel Deployment Scenario**

* [Moderator] In one company’s contribution [R4-2015860], it is proposed that tunnel deployment scenario should be considered for FR2 HST. Moderator suggest to collect more view and if the necessity is confirmed, companies can contribute to tunnel deployment scenario in next meeting.
* Proposal:
	+ Proposal (Ericsson): Clarify whether coverage is provided in tunnels and if so, the assumed deployment.
* Recommended WF:
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-2: Antenna Array Parameters

*Sub-topic description*

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

**Issue 2-2-1: RRH antenna array parameters for evaluation**

* Proposals:
	+ RAN1 assumption: 2 ports: [Mg, Ng, M, N, P]=[1, 1, 4, 8, 2]
	+ 2 ports: [Mg, Ng, M, N, P]=[1, 1, 8, 8, 2]
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-2-2: RRH antenna element parameters for evaluation**

* Proposals:
	+ Proposal 1 (Ericsson): Assume the following table (originally for UE in RAN1 evaluation) for BS:

|  |  |
| --- | --- |
| Parameter | Values |
| Antenna element radiation pattern in  dim (dB) |  |
| Antenna element radiation pattern in  dim (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 5dBi |

* + RAN1 assumption for BS evaluation:

|  |  |  |
| --- | --- | --- |
| **Radiation power pattern of a single antenna element for TRP** | Vertical cut of the radiation power pattern (dB) |  |
| Horizontal cut of the radiation power pattern (dB) |  |
| 3D radiation power pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 8 dBi |

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

**Issue 2-2-3: UE antenna array parameters for evaluation**

* Proposals:
	+ RAN1 assumption: 2 ports: [Mg, Ng, M, N, P]=[1, 1, 2, 4, 2]
	+ PC4 assumption: 2 ports: [Mg, Ng, M, N, P]=[1, 1, 4, 4, 2]
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-2-4: RRH antenna element parameters for evaluation**

* Proposals:
	+ RAN1 assumption:

|  |  |
| --- | --- |
| Parameter | Values |
| Antenna element radiation pattern in  dim (dB) |  |
| Antenna element radiation pattern in  dim (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 5dBi |

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

### Sub-topic 2-3: FR2 HST Channel Modeling

*Sub-topic description*

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

**Issue 2-3-1: Pathloss model used for link budget evaluation**

* Proposals:
	+ Option-1: TR38.901 RMa NLOS
	+ Option-2: TR38.901 RMa LOS
	+ Option-3: free space model
	+ Option-4: TR38.901 UMa LoS
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-3-2: Channel modelling for performance requirements:**

* Proposals:
	+ Option 1: single-tap per RRH channel model in UL direction and both single- and multi-tap models in DL direction.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-4: FR2 HST Feasibility Evaluation

*Sub-topic description*

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

**Issue 2-4-1: Aspects for FR2 HST Feasibility Evaluation:**

* Proposals for beam coverage, beam overlapping, and mobility feasibility:
	+ Proposal 1 (Qualcomm): Evaluate the feasibility of a deployment based the above beam dwelling time and measurement period framework.
		- How many beams/SSBs per RRH can be deployed (given other deployment parameters such as Dmin, Ds, speed etc) while maintain mobility performance with FR2 BM mechanism?
		- How much beam overlapping area is needed (given other deployment parameters such as Dmin, Ds, speed etc) to ensure beam refinement procedure can be executed successfully?
	+ Proposal 2 (Samsung): Based on assumed deployment scenario, the analog beam coverage for multi-RRHs deployment should be designed to consider the tradeoff between throughput performance and mobility performance.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-4-2: Feasibility Study of Supported High Speed Train Velocity**

* Proposals and observations:
	+ Observations (Huawei):
		- Observation 1: for UL DM-RS 1+1+1: consider both UL and DL together and the UL limitation: the supported max velocity = 252km/h with DL fd = 7kHz and UL fd = 14kH with assumption of no positive to negative Doppler jump
		- Observation 2: for UL DM-RS 1+1+1+1: consider both UL and DL together and the UL limitation: v = 335km/h with DL fd = 9.3kHz and UL fd = 18.7kH with assumption of no positive to negative Doppler jump
		- Observation 3: No limitation for PRACH to support 350km/h velocity with carrier frequency 30GHz, i.e. max Doppler shift 9.7kHz for FR2 HST.
	+ Observation and Proposal (Nokia):
		- Observation: The distance between consecutive DM-RS symbols shall not be above 3 to support 350kmph train speed. Hence, at least 3 DM-RS symbols per slot should be used. 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: RAN4 to evaluate two maximum train speeds: 260 and 350 kmph.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1: Sub topic 1-2:….Others: |
| Ericsson | Issue 2-1-1: Proposal 1 captures a range of scenarios. We think this range of scenarios is reasonable for now so that the impact of link budget on Ds as well as the achievable speed dependency on Dmin can be elaborated. Potentially the RRH height could be fixed at e.g. 15m to reduce the number of combinations. Considering the bullet below, we understand that Dmin is considered as 10m as baseline but also 20, 30, 50m should be investigated; is this the common understanding ?Issue 2-1-2: There are some differences to FR1 considering the beamforming; e.g. SFN combining at the UE cannot be achieved in opposite directions for a bi-directional deployment. Also, bi-directional will cause a rapid change in UE panel and Doppler, which may impact the supportable speed. We suggest considering uni-drectional as baseline, but checking if bi-directional is supportable and the maximum speed.Issue 2-1-3: This depends somewhat on link budget evaluations; our prelimnary view is option 1+3Issue 2-1-4: Depends on deployment scenarios agreed.Issue 2-1-5: RAN4 should possibly investigate impact on UE for the different shared vs. separate SSBs per beams per RRHsIssue 2-1-6: Option 1 for bi-directional, option 2 for uni-directional.Issue 2-1-7: Option 1 for uni-directional, option 2 for bi-directionalIssue 2-1-8: Not clear how much this impacts the analysis and requirements.Issue 2-1-9: This should be decided after more detailed analysis of RRM and demodulation performance. It does not need to be decided in this meeting as it is not really part fo the deployment scenario.2-1-10: We do not promote the tunnel scenario but believe it should be clarified whether it is included or not and if so, how the parameters would look.Issue 2-2-1: Seems OKIssue 2-2-3: Seems OKIssue 2-2-4: Seems OKIssue 2-3-1: LoS model should be considered. Option 4 makes most sense.Issue 2-3-2: Option 1 OKIssue 2-3-3: The proposals do not seem to contradict one another. Link budget and throughput performance as well as mobility needs to be considered and an appropriate trade-off found.Issue 2-4-2: DM-RS design is beyond considering deployment scenario. The theortical calculations make sense, but more link budget evaluation is needed. Relarding the proposal to evaluate two maximum speeds; it may be better stated as evaluate the maximum achievable speed for the identified deployment scenarios. Of course, these maximum speeds may then be compared to 260/350km/h, but it is useful to know what the maximum speeds are. |
| Verizon | Issue 2-1-1: Proposal-1Issue 2-1-2: Option-2 and want to check option 3 tooThis has considered, in reality, the train will move on bidirectional on the tracks. In this scenario, it seems the SFN combining at the UE would be more challenge in opposite directions comparing with the uni-directional deployment. Therefore, some detail study may be very useful.Issue 2-1-3: Option 3 + 4Issue 2-1-4: Investigation is needed Issue 2-1-5: Investigation is neededIssue 2-1-6: Option 1Issue 2-1-7: : Investigation is neededIssue 2-1-8: : Investigation is neededIssue 2-1-9: Option 1 (preferred)Issue 2-1-10: Should consider the tunnel scenario Issue 2-2-1: Based on the companies inputIssue 2-2-2: Based on the companies inputIssue 2-2-3: Proposal is okIssue 2-2-4: Proposal is okIssue 2-3-1: Option 2 or 4Issue 2-3-2: Proposal is okIssue 2-4-1: Proposal 2 + proposal 1  |
| QC | Issue 2-1-1: We want to point out that with small Dmin relative to Ds, train is always straight in front of RRH or straight behind RRH, no direction change and two beams with opposite directions are enough to cover the whole track. However, the consequence is that beam coverages of two consecutive RRHs are completely overlapped (if path loss is not considered), UE receives signal from both RRH, then it becomes the HST-SFN scenario discussed in FR1. Then all the constraints RAN4 discussed in FR1 apply to FR2, which can significantly limit the maximum speed, given high carrier frequency is used.Issue 2-1-3:Is number of RRHs per BBU relevant from RAN4 requirement perspective? We don’t understand what requirement can be affected. Both RRM, demod and RF requirements are based on Ds, independent of number of RRHs per BBU.Issue 2-1-4:This depends on ratio between Ds and Dmin, and how fast UE can perform beam management (overlapping area) and mobility measurement (beam dwelling time), as we analyzed in our contribution.Issue 2-1-5:Same as issue 2-1-5, it’s not clear how the indexes mapping can affect requirement, before we discuss this issue, the impact must be identified.Issue 2-1-6, 2-1-7:This depends on whether uni-directional or bi-directional deployment is agreedIssue 2-1-8:Same comment as 2-1-5.Issue 2-3-2:This depends on whether bi-directional or uni-directional channel is selected. |

### 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** |
| R4-2014848 | Samsung | Observation-1: RAN4 need to identify if there are any specific limitations or additional requirements that shall be defined on the basis of PC4 requirement, e.g., whether or not the current FR2 power class 4 UE can be used for the targeted FR2 HST scenario. Obervation-2: To consider the particular application scenario for FR2 HST, there are two approaches RAN4 can adopt to specify UE RF core requirement: - Approach-1: Provide an applicability rule of FR2 PC4 for the train-roof-mounted UE for FR2 HST scenario, i.e., the applicable FR2 PC4 requirement set for FR2 HST scenario.  - Approach-2: Revisit the full set of UE RF requirements for FR2 PC4 UE. |
| R4-2015087 | Nokia, Nokia Shanghai Bell | Observation 1: It is preferred to reuse the existing PC4 requirement as much as possible.Observation 2: The better beam correspondence requirement than PC3 is required for FR2 HST. |
| R4-2016058 | Ericsson | Proposal 1: RAN4 shall agree and settle deployment scenario(s)/assumptions before any UE RF core requirements are decided. |
| R4-2016538 | Huawei, HiSilicon | Observation 1: PC4 is within upper limitation of TRP 23dBm and EIRP 43dBm.Proposal 1: the min peak EIRP for FR2 HST UE follows the agreement for PC5. |

## 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 for FR2 HST**

* Proposals and observations
	+ Observations (Nokia):
		- Observation 1: It is preferred to reuse the existing PC4 requirement as much as possible.
		- Observation 2: The better beam correspondence requirement than PC3 is required for FR2 HST.
	+ Observation (Samsung): RAN4 need to identify if there are any specific limitations or additional requirements that shall be defined on the basis of PC4 requirement, e.g., whether or not the current FR2 power class 4 UE can be used for the targeted FR2 HST scenario.
	+ Proposal (Huawei): The min peak EIRP for FR2 HST UE follows the agreement for PC5.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 3-1-2: Approach to specify UE RF requirement:**

* For the particular application scenario for FR2 HST, how to specify UE RF core requirement:
	+ Option-1: Provide an applicability rule of FR2 PC4 for the train-roof-mounted UE for FR2 HST scenario, i.e., the applicable FR2 PC4 requirement set for FR2 HST scenario.
	+ Option-2: Revisit the full set of UE RF requirements for FR2 PC4 UE.
	+ Option-3: New RF requirement is defined for FR2 HST UE which is different from PC4, specifically, the min peak EIRP for FR2 HST UE follows the agreement for PC5(new FR2 FWA UE).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX | Sub topic 1-1: Sub topic 1-2:….Others: |
| Ericsson | Issue 3-1-1: PC4 probably makes sense as a baseline. However, the spherical coverage etc. will depend on the deployment scenario, which should be evaluated first. If in the end the spherical coverage differs, does it make sense really to squeeze this type of device into PC4 with some different parameters or rather define it as a PC in it’s own right ? (Or maybe PC4-HST…)Issue 3-1-2: Instead of an applicability rule to migrate PC4 towards HST, it may make sense to create an HST power class. Firstly we should see how different the RF requirements look though. |
| Verizon | Issue 3-1-1: Use PC4 as baseline and further define the requirementsIssue 3-1-2: Option 1+2 |
| QC | A general comment for both issues:What RF requirements, including EIRP and spherical coverage and more, to apply on FR2 HST UE highly depends on the deployment scenario, as it decides where DL beam is coming from and UL beam is pointing to, as well as pathloss and link budget. Hence we should come back to these issues after deployment scenario is settled. |

### 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”* |