**3GPP TSG-RAN WG4 Meeting #102-e R4-22xxxxx**

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

**Title:** WF on demodulation requirement for Enhancement on HST-SFN deployment

**Source:** Intel Corporation

**Agenda item:** 10.19.4

**Document for:** Approval

# Introduction

This WF capture all agreements and open issues for the following topics in [102-e][330] NR\_FeMIMO\_Demod:

* Topic #2: Demodulation requirement for Enhancement on HST-SFN scenario
  + Sub-topic 2-1: Test scope
  + Sub-topic 2-2: Test setup for PDSCH requirement for SFN scheme A with Single Carrier
  + Sub-topic 2-3: Test setup for PDSCH requirement for SFN scheme B with Single Carrier If introduced

The agreed WFs on demodulation performance requirements for enhancement on HST-SFN in the previous meetings:

* R4-2203091, “WF on demodulation requirement for Enhancement on HST-SFN deployment”, Intel, RAN4#101-bis-e

# Topic #2: Demodulation requirement for Enhancement on HST-SFN scenario

## Sub-topic 2-1: Test scope

**Issue 2-1-1: Whether to define PDCCH requirement for HST SFN scenario**

*Tentative agreement:*

* No PDCCH requirement for Enhancement on HST-SFN scenario.
* Define test case where both channels (PDSCH/PDCCH) are transmitted using SFN scheme and verify performance of PDSCH only

*Recommendations for 2nd round:*

Confirm tentative agreement

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| **Company** | **Comments** |
| Samsung | We are ok with tentative agreement made in 1st round |
| CMCC | OK with the tentative agreement |
| Apple | We support the tentative agreement. |
| Intel | We support the tentative agreement. |
| Qualcomm | Okay with the tentative agreement. |

**Issue 2-1-2: Whether to define PDSCH requireemnt with HST-SFN scheme B**

*Candidate options:*

* Option 1: Yes
  + Option 1a: scheme A and scheme B with test applicability rule: If UE pass HST-SFN scheme A test cases, UE can skip HST-SFN scheme B test cases
  + Option 1b: scheme A and scheme B with test applicability rule: If UE supporting both HST SFN scheme A and B and supporting both 15kHz SCS and 30kHz SCS, then UE shall only pass schemeA 15kHz and schemeB 30kHz requirements.
* Option 2: No
* Option 3: do not introduce PDSCH requirements for SFN scheme B and define the following test applicability rule to guarantee performance with this scheme:
  + If UE passes the existing test cases (demodulation requirement for HST-SFN with high Doppler shift), the performance of SFN scheme B is guaranteed

*Recommendations for 2nd round:*

* Encourage comments if any
* Encourage companies to further discuss with following aspects
  + UE feature list with HST SFN scheme A and scheme B
  + Channel model with scheme A and scheme B
  + QCL type with two TCI states for scheme A and scheme B
  + UE receiver processing with scheme A and scheme B
  + Channel model with scheme B compared with single tap HST or DPS
  + UE receiver processing of scheme B compared with single tap HST or DPS

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| **Company** | **Comments** |
| Samsung | We support option 1  As commented in 1st round we do see the obviously different compared with scheme A and B, in terms of UE feature list, receiver processing and channel model, QCL type information  Considering the test effort, the test applicability rule can be introduced for scheme A and B, i.e.,  If UE pass HST-SFN scheme A, UE can skip HST-SFN scheme B.  Regarding the option 3, as mentioned, scheme A/B do not need the advanced receiver compared with Rel-16 HST SFN pending on UE capability, the channel model and UE processing with different TCI state with QCI type information is different with Rel-16 HST SFN. UE support scheme B, while not support advanced receiver, the performance can be guaranteed. |
| CMCC | We support to define PDSCH requirement with HST-SFN scheme B to guarantee UE demodulation performance. As for the applicability rule between HST-SFN scheme A test cases and HST-SFN scheme B test cases, we are open to discussion. |
| Huawei | We support Option 1.  We prefer Option 1. For Rel-17 SFN scheme B, UE is configured with two set of delay-related parameters corresponding to different TCI state and one set of Doppler-related parameters corresponding to the reference TCI state. Considering different TRS configuration, different UE processing is expected comparing to the Rel-16 DPS.  For the applicability rule, we can consider similar method as Rel-17 HST to ensure test coverage and reduce the test effort at the same time, such as following:   * If UE supporting both HST SFN scheme A and B and supporting both 15kHz SCS and 30kHz SCS, then UE shall only pass schemeA 15kHz and schemeB 30kHz requirements.  |  |  |  |  | | --- | --- | --- | --- | | **UE is capable of** | **HST-SFN schemeA only** | **HST-SFN schemeB** **only** | **Both HST-SFN schemeA and schemeB** | | **15kHz only** | Case1: schemeA 15kHz | Case2: schemeB 15kHz | Case1: schemeA 15kHz  Case2: schemeB 15kHz | | **30kHz only** | Case3: schemeA 30kHz | Case4: schemeB 30kHz | Case3: schemeA 30kHz  Case4: schemeB 30kHz | | **Both 15kHz and 30kHz** | Case1: schemeA 15kHz  Case3: schemeA 30kHz | Case2: schemeB 15kHz  Case4: schemeB 30kHz | Case1: schemeA 15kHz  Case4: schemeB 30kHz | |
| Apple | We support option 2 – no requirements.  There is no enhanced receiver required for UE for SFN Scheme B. The UE should process this similar to single tap HST. The performance requirements should be for gNB to ensure correct pre-compensation is applied, rather than for UE. |
| Intel | We have several questions on test definition for SFN Scheme B. Please see our comments for issue 2-3-2. At current stage we do not see how we can define test that can differentiate conventional UE (that does not assume specific DL/UL QCL) and HST-SFN scheme B capable UE. Support Option 2 at this stage. |
| Qualcomm | Option 2. Since PDSCH will be Doppler pre-compensated, our understanding is that it does not impact the UE demod processing in a meaningful way that requires defining requirements for this scheme. Furthermore, we think that after Doppler pre-compensation, channel seen by UE would be similar to a single tap channel, for which we already defined performance in Rel-16. |

**Issue 2-1-3: Whether to define PDSCH CA requirement for Enhancement on HST SFN scnearion**

*Tentative agreements*

* No PDSCH CA requirement for Enhancement on HST SFN scenario in Rel-17 FeMIMO WI.

*Recommendations for 2nd round:*

Confirm tentative agreement

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| **Company** | **Comments** |
| Samsung | We are ok the tentative agreement made in 1st round discussion |
| CMCC | OK with the tentative agreement |
| Apple | We support the tentative agreement. |
| Intel | We support the tentative agreement. |
| Qualcomm | Okay with the tentative agreement |
| DoCoMo | OK with the tentative agreement |

## Sub-topic 2-2: Test setup for PDSCH requirement for SFN scheme A with Single Carrier

**Issue 2-2-1: Common setup for PDSCH requirement**

*Tentative agreements*

* Reuse existing Rel-16 HST-SFN test set-up as a baseline
  + PDCCH/PDSCH SFN transmitted from two RRHs

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| Parameter | Value | |
| FDD 15 kHz SCS | TDD 30 kHz SCS |
| CBW | 10 MHz | 40 MHz |
| Antenna configuration | 2x2; 2x4 | |
| DMRS type | Type 1 | |
| Number of DMRS symbols | 1+1+1 | |
| TDD pattern |  | 7D1S2U, S: 6D 4G 4U |
| TRS configuration | 10ms, 2 slot pattern | |
| PDSCH mapping | Type A, Start symbol 2, Duration 12 | |
| Ds and Dmin | Ds =700m; Dmin=150m | |
| Test metric | SNR @70% of maximum throughput | |

*Recommendations for 2nd round:*

Confirm tentative agreement

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| **Company** | **Comments** |
| Samsung | We are ok with the tentative agreement made in 1st round discussion |
| CMCC | OK with the tentative agreement |
| Apple | We support the tentative agreement. |
| Intel | We support the tentative agreement. |
| Qualcomm | Okay with the tentative agreement |
| DoCoMo | OK with the tentative agreement. |

**Issue 2-2-2: Number of TCI codepoint for Test**

*Candidate options:*

* Option 1: TCI state 1 and TCI state 2 applied for TRP/RRH #2n, #2n+1 separately; TRS 1 and TRS 2 transmitted from TRP#2n, and #2n+1 separately
* Option 2: Configure 4 TCI code point during test, transmit TRS#i from RRH#4k+i that i = 0, 1, 2, 3 and k = 0, 1, 2, … .
  + Codepoint#0 active when UE receiving PDSCH from RRH#4k and RRH#4k+1 : TCI#0, TCI#1
  + Codepoint#1 active when UE receiving PDSCH from RRH#4k+1 and RRH#4k+2: TCI#1, TCI#2
  + Codepoint#2 active when UE receiving PDSCH from RRH#4k+2 and RRH#4k+3: TCI#2, TCI#3
  + Codepoint#3 active when UE receiving PDSCH from RRH#4k+3 and RRH#4(k+1): TCI#3, TCI#0
* Option 3: Configure 3 TCI code point during test, transmit TRS#i from RRH#3k+i that i = 0, 1, 2 and k = 0, 1, 2, … based on two RRHs
  + Codepoint#0 active when UE receiving PDSCH from RRH#3k and RRH#3k+1 : TCI#0, TCI#1
  + Codepoint#1 active when UE receiving PDSCH from RRH#3k+1 and RRH#3k+2: TCI#1, TCI#2
  + Codepoint#3 active when UE receiving PDSCH from RRH#3k+2 and RRH#3(k+1): TCI#2, TCI#0

*Recommendations for 2nd round:*

Encourage comments if any

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| **Company** | **Comments** |
| Samsung | We can go option 3, since only 2RRH considered in then channel model, it seems that 3 TCI code point is enough. |
| Huawei | We are OK with either Option 2 or Option3. |
| Apple | Either option 3 or option 2 works. We can go with option 3 since it would be sufficient for the test purpose. |
| Intel | We slightly prefer Option 3 that has smaller number of TCI states compared to Option 2. |
| Qualcomm | Option 3. We think that 3 TCI states is enough since UE would be receiving transmission from at most 2 RRHs simultaneously. |

**Issue 2-2-3: Maximum Doppler shift**

*Tentative agreements:*

* Define PDSCH requirement with HST-SFN scheme A with Maximum Doppler shift
  + 30KHz SCS: 1667Hz
  + 15 kHz SCS:
    - Option 1: 972 Hz
    - Option 2: 840 Hz
    - Companies are encouraged to bring simulation results with both option 1 and option 2 to check whether there is performance degradation with option 1, down selection one of them in the next meeting

*Recommendations for 2nd round:*

Encourage comments if any

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| **Company** | **Comments** |
| Samsung | In general, both option 1 and option 2 are within the capability of TRS Doppler tracking, option 2 is the same as Rel-16 HST-SFN with majority companies supported, we support option 2. We are open to further discuss  we can regard as baseline, and to check the simulation results with both option 1 and option2, if there is no obvious performance degradation, either option 1 and option 2 are fine for us, otherwise, option 2 is more preferable |
| CMCC | We are OK with the tentative agreement. If there is no performance degradation with option 1 based on the simulation results, option 1 is OK for us. |
| Huawei | We support Option 2. The maximum Doppler jump should be within the maximum UE capability for FOE based on TRS. |
| Apple | We should assume option 2 as baseline which is similar to HST-SFN. We need to further evaluate if higher max Doppler can be supported without performance degradation. Since this is different from single tap HST, we prefer lower max Doppler shift. |
| Intel | We support the tentative agreement to perform study next meeting and decide Doppler frequency for 15 kHz based on simulation results. |
| Qualcomm | We support 870 Hz for 15KHz SCS. (Is there a typo here? Could the proponent of this WF check whether it should be 870 Hz for option 2?)  Our understanding is that the difference between the estimated Dopplers for TRP#1 (i.e., estimated from TRS1) and TRP#2 (i.e., estimated from TRS2) should still be within the TRS pull-in range. Furthermore, UE has to come up with a mechanism to make use of the estimated Dopplers from two TRSs. Therefore, in our view, the assumption of single-tap model, for which a higher Doppler is assumed (option 2) is not applicable here. Hence, we also think it is not necessary to study 972 Hz Doppler model here. |
| DoCoMo | We are OK with the tentative agreement. (We also think that 840Hz is typo.) |
| SoftBank | We are fine with the tentative agreement. |

**Issue 2-2-4: MCS and Rank**

*Tentative agreements:*

* Define PDSCH requirement with HST-SFN scheme A with MCS 17 and Rank 2 from MCS Table 1

*Recommendations for 2nd round:*

* Confirm tentative agreement

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| **Company** | **Comments** |
| Samsung | Ok with tentative agreement made in 1st round discussion |
| CMCC | OK with the tentative agreement |
| Apple | We support the tentative agreement. |
| Intel | We support the tentative agreement. |
| Qualcomm | Okay with the tentative agreement |

**Issue 2-2-5: Channel Model**

*Tentative agreements:*

* Reusing the existing Rel-16 HST-SFN channel model (Ds=700m, Dmin=150m) with removing the two furthest paths corresponding to the two furthest TRP as baseline
* For PDCCH and PDSCH HST-SFN with 2 nearest RRH, including time varying path power and path delay
* For TRS, single tap from each RRH, including time varying path power and path delay, apply the same scaling as PDSCH for each TRP for path power, and apply the same delay as PDSCH for each TRP for path delay, and apply the same time-varying Doppler shift from each RRH as PDCCH/PDSCH for Doppler shift

*Recommendations for 2nd round:*

Confirm tentative agreement

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| **Company** | **Comments** |
| Samsung | Ok with tentative agreement made in 1st round discussion. Meanwhile, encourage companies to further check the wording whether there is anything missing |
| Apple | We support the tentative agreement. |
| Intel | One clarification can be added as: total path power is normalized assuming only two visible TRPs. It is important to have the same SNR assumption as in Rel-16 HST-SFN. |
| Qualcomm | Okay with the tentative agreement |
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**Issue 2-2-6: Baseline receiver for defining scheme A requirement**

*Candidate options:*

* Option 1: Confirm the assumption that the HST-SFN advanced receiver is the baseline receiver for defining scheme A requirement
* Option 2: Do not assume HST-SFN advanced receiver is the baseline receiver for defining scheme A requirement

*Recommendations for 2nd round:*

Encourage comments if any

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| **Company** | **Comments** |
| Samsung | As mentioned in 1st round, the channel model and UE processing is different with HST-SFN and scheme A, meanwhile the UE feature is different with different UE capability, one is target as Rel-16, another is targeting as Rel-17, it is not proper to use the HST-SFN advanced receiver as the baseline receiver  We support option2, the legacy receiver to handle the Doppler tracking, similar as in single path or DPS scheme, can be considered |
| Huawei | We support Option 2. There is different UE processing is expected comparing to the Rel-16 HST-SFN. |
| Apple | We cannot agree to assume HST-SFN advance receiver as baseline receiver for HST SFN Scheme A, nor do we expect UE to support it without any advanced receiver. UE support of this would assume some advanced receiver indicated by UE capability of supporting this feature. |
| Intel | Similar view as Apple. |
| Qualcomm | Rel-17 HST-SFN Scheme A will require different processing at the UE side compared to that of Rel-16 HST-SFN. Therefore, our understanding is that Rel-16 HST-SFN advanced receiver can’t be assumed as a baseline for Rel-17 HST-SFN Scheme A. Therefore, we can’t support option 1.  On the other hand, option 2 seems to suggest that legacy receiver can be assumed, which we don’t agree with since the subsequent processing for demodulation purpose could be different compared to single-tap and DPS channels. |

**Issue 2-2-7: UE capabilty**

*Candidate options:*

* Option 1: The PDSCH demodulation requirements for HST-SFN Scheme A is applicable for UE capable of ‘SFN Scheme A’.

*Recommendations for 2nd round:*

Pending on conclusion of UE feature list of Rel-17 FeMMO

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| **Company** | **Comments** |
| Samsung | Based on RAN1 agreement about UE feature list discussion in Rel-17 FeMIMO, scheme A is UE optional with capability signaling, we support option 1 |
| Apple | We believe RAN1 capability should be sufficient, but we can defer this to when RAN1 UE feature discussion is finalized. |
| Intel | Support Option 1. |
| Qualcomm | We prefer to revisit this after RAN1 finalizes defining UE capability for Scheme A. |

**Issue 2-2-8: Performance evalution**

*Candidate options:*

* Option 1: Evaluate performance improvement of HST SFN scheme A over Rel-16 HST SFN.

*Tentative agreements:*

* Interested companies can provide the performance evaluation result of HST SNF scheme A over Rel-16 HST SFN. No impact on the Rel-17 HST SFN scheme A performance requirement definition.

*Recommendations for 2nd round:*

Confirm tentative agreement

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| **Company** | **Comments** |
| Samsung | Since RAN1 have already verified the benefit of scheme A compared with Rel-16 |
| Apple | We support the tentative agreement. |
| Intel | We support the tentative agreement. |
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## Sub-topic 2-3: Test setup for PDSCH requirement for SFN scheme B with Single Carrier If introduced

**Issue 2-3-1: Common setup for PDSCH requirement**

*Candidate options:*

* Option 1: Reuse existing Rel-16 HST-SFN test set-up as a baseline
  + two TCI states with one configured QCL type A information, and another one configured QCL Type B information’
  + TCI state 1 and TCI state 2 applied for TRP/RRH #2n, #2n+1 separately; TRS 1 and TRS 2 transmitted from TRP#2n, and #2n+1 separately

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| Parameter | Value | |
| FDD 15 kHz SCS | TDD 30 kHz SCS |
| CBW | 10 MHz | 40 MHz |
| Antenna configuration | 2x2; 2x4 | |
| DMRS type | Type 1 | |
| Number of DMRS symbols | 1+1+1 | |
| TDD pattern |  | 7D1S2U, S: 6D 4G 4U |
| TRS configuration | 10ms, 2 slot pattern | |
| PDSCH mapping | Type A, Start symbol 2, Duration 12 | |
| Ds and Dmin | Ds =700m; Dmin=150m | |
| Test metric | SNR @70% of maximum throughput | |

*Recommendations for 2nd round:*

* Pending on issue 2-1-2

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| **Company** | **Comments** |
| Samsung | As commented in issue 2-1-2, we think it is necessary to define performance requirement with scheme B to verify the proper receiver to tracking the delay of each RRH with different TCI state  As for common setup, we are ok to further discuss the number of TCI state configuration. For other parts, we apply the same configuration as scheme A |
| CMCC | OK with option 1. |
| Intel | We support to consider Option 1 as a baseline. |

**Issue 2-3-2: Modeling of TRP pre-compensation**

*Candidate options:*

* Option 1: For scheme B, BS behaviour can be Doppler Modeling into channel model so that TE implementation of pre-compensation has no impact on the UE performance during the test.

*Recommendations for 2nd round:*

* Pending on issue 2-1-2

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| **Company** | **Comments** |
| Samsung | In general, we are ok with option 1, For test, we prefer there is no Doppler modeling, only including the path delay and part power for each RRH  Even with residual Doppler shift, generated by TE due to the test uncertainty, my understanding the impact is minor |
| Huawei | We prefer to consider Doppler in the channel model. There may be maximum 0.4ppm residual frequency based on our calculation for the worst case. We think it is benefit to explicitly model the Doppler into channel model to verify whether UE can correctly handle it. |
| Intel | At current stage we do not understand completely how BS pre-compensation can be a part of channel model.  At the beginning of the test UE observes different Doppler shifts on each TRS. After what time period Doppler shifts will be aligned? Then due to UE movement there should be further misalignment of Doppler shifts and further adjustments of them in channel model. What is the time granularity of these processes and how UE behavior affect them?  Another question is how wrong UE can fail the test? In case there is no feedback between channel model change and UE processing (that should emulate SRS Tx with certain periodicity with QCL on reference TRP) it is not clear how UE can fail the test in case it has conventional UE Rx processing.  If we are going to define just two tap channel model with aligned Doppler shifts (even with some small difference due to frequency error of gNB Tx) there is no big difference from multi-path fading propagation conditions and conventional UE will also pass the test. |

**Issue 2-3-3: Number of TCI codepoint for Test**

*Candidate options:*

* Option 1: TCI state 1 and TCI state 2 applied for TRP/RRH #2n, #2n+1 separately; TRS 1 and TRS 2 transmitted from TRP#2n, and #2n+1 separately
* Option 2: Configure 4 TCI code point during test, transmit TRS#i from RRH#4k+i that i = 0, 1, 2, 3 and k = 0, 1, 2, … .
  + Codepoint#0 active when UE receiving PDSCH from RRH#4k and RRH#4k+1 : TCI#0, TCI#1
  + Codepoint#1 active when UE receiving PDSCH from RRH#4k+1 and RRH#4k+2: TCI#1, TCI#2
  + Codepoint#2 active when UE receiving PDSCH from RRH#4k+2 and RRH#4k+3: TCI#2, TCI#3
  + Codepoint#3 active when UE receiving PDSCH from RRH#4k+3 and RRH#4(k+1): TCI#3, TCI#0
* Option 3: Configure 3 TCI code point during test, transmit TRS#i from RRH#3k+i that i = 0, 1, 2 and k = 0, 1, 2, … based on two RRHs
  + Codepoint#0 active when UE receiving PDSCH from RRH#3k and RRH#3k+1 : TCI#0, TCI#1
  + Codepoint#1 active when UE receiving PDSCH from RRH#3k+1 and RRH#3k+2: TCI#1, TCI#2
  + Codepoint#3 active when UE receiving PDSCH from RRH#3k+2 and RRH#3(k+1): TCI#2, TCI#0

*Recommendations for 2nd round:*

* Pending on issue 2-1-2

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| **Company** | **Comments** |
| Samsung | As mentioned issue 2-2-2, we can go option 3 with configure 3 TCI code point during the test. |
| Huawei | We are OK with either Option 2 or Option3. |
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**Issue 2-3-4: MCS and Rank**

*Candidate options:*

* Option 1: MCS 17 with Rank 2

*Recommendations for 2nd round:*

* Pending on issue 2-1-2

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| **Company** | **Comments** |
| Samsung | We support option 1 as baseline |
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**Issue 2-3-5: Channel Model**

*Candidate options:*

* Option 1:
  + Reusing the existing Rel-16 HST-SFN channel model (Ds=700m, Dmin=150m) with removing the two furthest paths corresponding to the two furthest TRP as baseline
  + HST SFN channel model specified in B.3.2 of TS 38.101-4 reused without modelling Doppler shift

*Recommendations for 2nd round:*

* Pending on issue 2-1-2
* Reusing the existing Rel-16 HST-SFN channel model (Ds=700m, Dmin=150m) with removing the two furthest paths corresponding to the two furthest TRP as baseline
* For PDCCH and PDSCH HST-SFN with 2 nearest RRH, including time varying path power and path delay, without modelling Doppler shift
* For TRS, single tap from each RRH, including time varying path power and path delay, apply the same scaling as PDSCH for each TRP for path power, and apply the same delay as PDSCH for each TRP for path delay, FFS modelling Doppler shift

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| **Company** | **Comments** |
| Samsung | As commented in previous, we support to define requirement with scheme B.  If it can be agreed, channel model recommended is preferred |
| Huawei | Similar view as Issue 2-3-2. |
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# Reference

1. R4-2207177, Email discussion summary for [102-e][330] NR\_FeMIMO\_Demod, RAN4#102-e, Samsung