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

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

**Title: WF on general and NTN UE demodulation requirements**

**Source: Qualcomm Incorporated**

**Agenda Item: 10.13.6.1& 6.13.6.3& 10.13.6.4**

**Document for: Approval**

# Introduction

According to the email discussion summary in [1], this document is to capture the WF on general and NTN UE demodulation requirements.

# WF on general aspects

**Issue 1-1-1: Power control model**

* Agreement:
	+ Only consider fixed SNR at the UE or BS side to facilitate testing even if the SNR may be changed in the real network

**Issue 1-1-2: UE speed**

* Agreement:
	+ Do not consider explicit model UE speed into channel model for NTN demodulation requirements.
	+ Companies are encouraged to check the impact of different UE speed on the simulation results.

# WF NTN UE demodulation and CSI reporting requirements

## 3.1 WF on general assumptions

**Issue 3-1-1: Channel model**

* Agreement:
	+ Select NTN-TDL-A and NTN-TDL-C for NTN UE demodulation requirements

**Issue 3-1-2a: Doppler shift model-UE pre-compensation**

* Proposals
	+ Option 1: Consider the UE pre-compensation for DL demodulation, i.e., the maximum doppler shift is residual frequency offset with a small value, e.g., 0.1ppm
	+ Option 2: Do not consider the UE pre-compensation for DL demodulation, i.e., the maximum doppler shift is total frequency offset (without Doppler compensation at the satellite), e.g., 24ppm
* Agreement:
	+ FFS whether to consider UE pre-compensation for DL demodulation, e.g., how to assume the frequency offset..

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| **Company** | **Comments** |
| Thales | It is difficult to answer since it is unclear to us what is meant exactly by UE pre-compensation for DL demodulation. Based on our understanding, RAN1 agreed to explicitly support UE self-estimated pre-compensation in both time and frequency for UL transmissions. However, the mechanisms mentioned here for DL demodulation remains unclear to us. Based on our understanding, it is possible to enable DL frequency and time reference tracking at UE side to be assisted by using satellite ephemeris related parameters shared by the network. Such enhancements would be left to the implementation. However, if such enhancement are implemented then it seems reasonable to consider them for DL demodulation. |
| Apple | We support option 1. Could proponents of option 2 please clarify what the purpose is to combine the DL pre-compensation into the demod requirements ? The purpose is to verify UE processing and reception of the DL channels in our understanding.  |
| Qualcomm | As we stated in the first round, our understanding is that unlike UL pre-compensation by UE, satellite can’t do a proper pre-compensation as the relative speed between satellite and UE is not known to the satellite, so we proposed to assume maximum Doppler (Option 1). We agree that assuming such a Doppler would mean that NTN UE would have to be able to correct this frequency shift, which could be very large. For Option 2, UE would compensate based on the estimated Doppler from satellite ephemeris and UE GNSS. Could the proponent of this proposal further clarify how this behavior will be modeled in the TE implementation? We are open to further discuss this issue. |
| Huawei | We prefer Option 1 by assuming the UE compensating Doppler behavior can be ensured by RAN1 design. For Option 2, maybe TE need to inform ephemeris to the UE and the UE position should be modeled into channel model. It seems more complexity, we are open to further discuss this method to reduce the test complexity. |
| Ericsson | Support Option 2. NTN UE could estimate the relative Doppler shift when it receives the signal, but it is not the relative Doppler when satellite was sending the signal. It is not clear that NTN UE have capability to furtherly estimate backward to the right time.  |

**Issue 3-1-2b: Doppler shift model- Frequency drift**

* Proposals
	+ Option 1: Consider the frequency drift for DL demodulation
	+ Option 2: Do not consider the frequency drift for DL demodulation
* Agreement:
	+ FFS on whether to consider the frequency drift for DL demodulation .

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| **Company** | **Comments** |
| Thales | The frequency drift can reach important values in LEO-based NTN which are never experienced in TN. It seems reasonable to consider it. Support Option 1. |
| Apple | We support Option 2. We assume that the Frequency drift/ Doppler shift is pre-compensated prior to UE baseband processing.  |
| Qualcomm | Can the proponent of Option 2 please clarify how the time varying frequency drift will be modeled in the TE implementation? |
| Huawei | Further discussion is needed until next meeting. |
| Ericsson | Further discussion is needed. Prefer FFS and left open to next meeting.  |

**Issue 3-1-3a: Delay spread model-maximum delay spread**

* Proposals
	+ Option 1: Single delay spread
		- Option 1a: 100ns
		- Option 1b: 250ns
	+ Option 2: Different delay spread
		- Option 2a: 10ns/50ns/150ns
		- Option 2b: 10ns/50ns/250ns.
* Agreement:
	+ FFS on maximum delay spread

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| **Company** | **Comments** |
| Thales | No strong opinion as long as the value considered are representative of realistic satellite LOS/NLOS channel model. |
| Apple | Is this max delay spread or RMS delay spread? We should consider 2 different delay spread values.  |
| Qualcomm | We support Option 1a.We think that 100ns is sufficiently large delay spread that captures a reasonable NLOS propagation scenario for NTN. |
| Huawei | We are Ok with either Option 1b or Option 2b. |
| Ericsson | We prefer taking 100ns as maximum DS based on Table 7.3.5.1.1-3 in TS38.811. We prefer only to define one DS value for each channel. For NLOS channel, the maximum DS could be considered. For LOS channel, smaller DS could be considered. For example NTN-TDLA100 and NTN-TDLC50.Table 7.3.5.1.1-3: Maximum delay spread and minimum coherence bandwidth for each deployment scenario

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|  | D1, GEO, Ka band | D2, GEO, S band | D3, LEO, S band | D4, LEO, Ka band | D5, HAPS, S band |
| **Maximum Delay spread (ns)** | 10 | 100 | 100 | 10 | 150 |
| **Min coherence bandwidth(NOTE 1, NOTE 2)** | >> MHz | 200 kHz | 200 kHz | >> MHz | 133 kHz |

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**Issue 3-1-3b: Delay spread model-Sampling frequency offset**

* Proposals
	+ Option 1: Consider sampling frequency offset for DL demodulation
	+ Option 2: Not consider sampling frequency offset for DL demodulation
* Agreement:
	+ FFS on sampling frequency offset

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| **Company** | **Comments** |
| Apple | We support option 2. Are we assuming that there will be a time varying propagation delay that is not compensated prior to baseband processing. Similar to the Doppler shift modeling, we should de couple this from demod requirements. Could proponents please clarify?  |
| Qualcomm | It is practical to consider sampling frequency offset to account for the time-varying propagation delay due to both satellite and UE movement. For example, the UE may drop or add samples, as necessary, based on the estimated sampling frequency offset. We don’t have a strong view on this and are open to support Option 2. However, we do think that if we continue to not consider NTN specific channel and propagation scenarios, at the end it really becomes a trivial TN UE demod scenario. |
| Huawei | Further discussion is needed until next meeting. |
| Ericsson | Further discussion is needed. Prefer FFS and left open to next meeting.  |

**Issue 3-1-4: Antenna configuration**

* Proposals
	+ Option 1: Only consider SAN 2Tx – UE 2Rx
	+ Option 2: In addition to SAN 2Tx – UE 2Rx, further consider SAN 1Tx – UE 2Rx and SAN 1Tx – UE 4Rx
* Agreement:
	+ Consider SAN 2Tx-UE 2Rx as the starting point.
	+ FFS on whether to consider SAN 1Tx – UE 2Rx and SAN 1Tx – UE 4Rx.

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| **Company** | **Comments** |
| Thales | We propose to consider SAN 1 or 2 TX using either circular polarization or linear polarization. SAN 1 TX is expected to be the most implemented scheme. |
| Qualcomm | We support Option 1.Also, can the proponents please clarify the use cases for 1Tx and 2Tx scenarios? |
| Huawei | We prefer Option 1. |
| Ericsson | OK with the recommended WF. |

## 3.2 WF on PDSCH requirements

**Issue 3-2-1: How to define the PDSCH requirements for GEO and LEO**

* Proposals
	+ Option 1: Only define requirements for LEO
	+ Option 2: Define requirements for GEO and LEO separately
	+ Option 3: Define one set requirements which are applicable for LEO and GEO (Moderator’s note: please explain how to define one requirement to apply for LEO and GEO if select this option)
* Agreement:
	+ FFS on how to define the PDSCH requirements for GEO and LEO

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| **Company** | **Comments** |
| Apple | We can first define requirements for LEO and see how they can be applicable to GEO if needed. We don’t prefer 2 sets of requirements for GEO and LEO.  |
| Qualcomm | We support Option 1.We think GEO satellite scenario mimics the legacy TN behavior; therefore, we prefer not to spend time on defining requirement for GEO. Also, given the dynamic behavior of the LEO satellite, i.e., satellite movement, we don’t think the same set of requirements can be applied for GEO. |
| Huawei | We are OK to only consider requirements for LEO. |
| Ericsson | Given many differences between GEO and LEO deployments that might affect performance, we prefer option 2. We are also open for option 3 with more clarification. |

**Issue 3-2-2:** **Enhancement on time relationship**

* Proposals
	+ Option 1: Provide the input for K\_offset values for GEO and LEO

Moderator’s note: It depends on issue 3-2-1.

* Agreement:
	+ Select the K\_offset value equal to or a little greater than the satellite-UE one-way delay. The detailed value should be selected after the channel model has been selected.
	+ FFS on the K\_offset values for GEO and LEO

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| **Company** | **Comments** |
| Qualcomm | We support the recommend WF. |
| Ericsson | OK with the recommended WF. |

**Issue 3-2-3: Enhancement on HARQ**

* Proposals: Do you agree to just verify the functionality with disabled HARQ, e.g., schedule a low code rate
	+ Option 1: Yes
	+ Option 2: No (please specify the reasons if any)
* Agreement:
	+ Disable HARQ with number of re-Tx set to 1 to avoid defining a special test as the start point

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| **Company** | **Comments** |
| Thales | Option 1 |
| Qualcomm | We support the recommend WF. |
| Ericsson | OK with the recommended WF. |

**Issue 3-2-4: SCS/CBW set for PDSCH requirements**

* Proposals
	+ Option 1: Only consider 15kHz SCS/10MHz
	+ Option 2: In addition to 15kHz SCS/10MHz, need to further consider 30kHz SCS: 20MHz

Moderator’s note: Do we need to align the SCS/CBW set for UL and DL?

* Agreement:
	+ Select 15kHz SCS/10MHz, further discuss whether to consider 30kHz SCS/ 20MHz

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| **Company** | **Comments** |
| Huawei | We still prefer Option 2. We think FDD 30kHz with 20MHz is also important.20220301: There is a typo. Correct to Option 2 from Option 1. |
| Apple | Option 1 is preferred to use same assumptions as normal PDSCH requirements. Does Huawei mean option 2? |
| Qualcomm | We support Option 1.TDD is not very practical for NTN scenarios due to timing issues. |
| Ericsson | We support option 1.  |

**Issue 3-2-5: Modulation order for PDSCH requirements**

* Proposals
	+ Option 1: Only consider QPSK and 16QAM
	+ Option 2: In addition to QPSK and 16QAM, need to further 64QAM
* Agreement:
	+ Consider QPSK and 16QAM, further discuss whether to consider 64QAM.

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| **Company** | **Comments** |
| Huawei | We still prefer Option 2. It is feasible for downlink 64QAM from the link budget point of view.20220301: There is a typo. Correct to Option 2 from Option 1. |
| Apple | We support option 1. We don’t think 64QAM is practical given low SNR conditions for NTN UE. Does Huawei mean option 2? |
| Qualcomm | We support Option 1. The operating SNR could be quite low in NTN communications to be able to support 64QAM transmission. |
| Ericsson | OK with the recommended WF. |

## 3.3 WF on PDCCH/PBCH assumptions

**Issue 3-3-1: Whether to define the PBCH requirements**

* Agreement: Do not define PBCH requirements

**Issue 3-3-2: Whether to define the PDCCH requirements**

* Agreement: Do not define PDCCH requirements

## 3.3 WF on CSI reporting assumptions

**Issue 3-4-1: CSI reporting requirements**

* Agreement: Do not define CSI reporting requirements

# Reference

[1] R4-2207442, Email discussion summary for [102][325] NR\_NTN\_Demod