3GPP TSG RAN WG1 #110 **R1-2207809**

Toulouse, France, August 22nd – 26th, 2022

Source: **Moderator (NTT DOCOMO, INC.)**

Title: **Summary #2 on 9.12.1 Coverage enhancement for NR NTN**

Agenda Item: **9.12.1**

Document for: **Discussion and Decision**

1. Introduction

This document is made for discussion on coverage enhancement for NR NTN. Schedule for discussion is below. FL requests companies to consider the schedule (but might be updated based on progress).

- 1st offline session: 15:30 – 16:30 on Monday
- 1st online session: 18:30 – 19:30 on Monday
- 2nd offline session: 14:30 – 15:30 on Thursday
- 2nd online session: 17:00 – 18:30 on Thursday
- 3rd online session: xxx

This topic is mentioned in Rel-18 NR NTN WID as captured in Appendix-1. In RAN1#109-e and RAN1#110, coverage performance under Rel-15/16/17 specifications is evaluated and whether NTN-specific techniques for coverage enhancement is necessary or not is concluded. FL assumes the following study plan for these purposes. It is noted that any perspective of technical enhancement will be discussed after the above study, if the necessity is clarified, though this perspective is briefly summarized in section 5.14.

- (Completed) RAN1#109-e: Agreements to have the same assumption for simulation evaluation
  - Target data rate
  - Evaluation methodology / Performance metrics
  - Link budget calculation
  - Satellite orbit
  - UE characteristics
  - Band / Bandwidth
  - Parameter set
  - Study cases
  - Targeted channels
  - Other assumptions
- RAN1#110: Agreements on whether enhancement is necessary for each channel / scenario
  - Which channel is insufficient for each scenario
  - Whether this agenda should discuss enhancement for the above identified channel / scenario

It is noted that, there was discussion on this topic at the last RAN plenary, and the conclusion was 'No TR, results will be captured in WI status reports'. That is, what we need to do in this meeting is just to agree the above to include them in chair's note. They will be captured in NTN WI status report and RAN plenary can have discussion and conclusion based on the status report.

In addition, 'contact information' in the last section is copied from the summary at the last meeting. Anyone can use/add/update/remove some of the list if necessary.

2. Collections of agreements/conclusions in RAN1#110

Conclusion

For Rel-18 coverage enhancement in NTN, NLOS environment is deprioritized.

3. Proposals for agreements/conclusions

16 Proposals

Proposal 15-1
For NR-NTN coverage enhancement,

- Alt 1: RAN1 concluded that GEO and MEO are de-prioritized in Rel-18.
- Alt 2: RAN1 concluded that GEO and MEO are de-prioritized for which it has been observed that it is challenging to enhance coverage for GEO and MEO in Rel-18 for the evaluated channels/signals.

Proposal 15-2
For NR-NTN coverage enhancement, link budget of parameter set-1 for LEO-1200 operating at LOS is considered as the target to evaluate whether each channel/signal with the existing specification needs to be enhanced or not. The targeted performances are used to evaluate the following services:

- VoIP using AMR 4.75 kbps. [This target should be met for an additional link budget margin of 3 dB, i.e., CNR is calculated with additional loss = 3 dB.]
- Low data rate of 3 kbps. This target should be met for an additional link budget margin of 3 dB, i.e., CNR is calculated with additional loss = 3 dB.
    - Note: this means that channels/signals are evaluated with the additional loss = 3 dB.

Proposal 2-1_v3

For PUSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS,

- Five sources observed that the existing specification can meet the performance requirement
- Eleven sources observed that the existing specification cannot meet the performance requirement with at least 0.3 dB gap

Alt 1: RAN1 concluded that enhancement of PUSCH for VoIP is unnecessary.

Alt 2: RAN1 concluded that enhancement of PUSCH for VoIP is difficult.

Alt 3: RAN1 concluded that PUSCH for VoIP should be enhanced.

Proposal 3-1_v3

For PUSCH for low data rate of 3 kbps with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Three sources observed that the existing specification cannot meet the performance requirement with at least 1.3 dB gap

RAN1 concluded that enhancement of PUSCH for low data rate of 3 kbps is unnecessary.

Proposal 4-1_v3

For Msg3 PUSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Three sources observed that the existing specification can meet the performance requirement
- Five sources observed that the existing specification cannot meet the performance requirement with at least 1.5 dB gap, unless Msg3 retransmission is scheduled

Alt 1: From RAN1 perspective, enhancement of Msg3 PUSCH is unnecessary.

Alt 2: RAN1 concluded that Msg3 PUSCH should be enhanced.

Proposal 5-1_v2

For PUCCH format 1 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Three sources observed that the existing specification can meet the performance requirement
- Three sources observed that the existing specification cannot meet the performance requirement with at least 1.6 dB gap

RAN1 concluded that enhancement of PUCCH format 1 is unnecessary.

Proposal 5-2_v2

For PUCCH format 3 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Two sources observed that the existing specification cannot meet the performance requirement with at least 2.4 dB gap

RAN1 concluded that enhancement of PUCCH format 3 is unnecessary.

Proposal 5-3_v2

For PUCCH for Msg4 HARQ-ACK with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification cannot meet the performance requirement with at least 2.8 dB gap

RAN1 concluded that PUCCH for Msg4 HARQ-ACK should be enhanced.

Proposal 6-4

For PRACH format 0 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Nine sources observed that the existing specification cannot meet the performance requirement with at least 2.2 dB gap

For PRACH format 2 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Seven sources observed that the existing specification cannot meet the performance requirement with at least 0.8 dB gap

For PRACH format B4 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Ten sources observed that the existing specification cannot meet the performance requirement with at least 4.2 dB gap

Alt 1: Whether/how specified for Rel-18 NTN coverage enhancement or not can be discussed after there is discussion progress in Rel-18 Further NR coverage enhancements Work Item.

Alt 2: RAN1 concludes that at least PRACH format 2 needs to be enhanced for NTN coverage enhancement.

Proposal 8-1_v2

For PDSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS without PFD limitation,

- Eight sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDSCH for VoIP is unnecessary, if PFD limit is not considered.

Proposal 10-1_v2

For Msg2 PDSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Two sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of Msg2 PDSCH is unnecessary, if PFD limit is not considered.

Proposal 10-2_v2

For Msg4 PDSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Two sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of Msg4 PDSCH is unnecessary, if PFD limit is not considered.

Proposal 11-1_v2

For PDCCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Seven sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH is unnecessary, if PFD limit is not considered.

Proposal 11-2_v0

For PDCCH of Msg4 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- One source observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH of Msg4 is unnecessary, if PFD limit is not considered.

Proposal 12-1_v2

For SSB with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Three sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH is unnecessary, if PFD limit is not considered.

Proposal 7-3_v0

RAN1 observed that if PFD limit is considered, the existing specification for PDSCH/Msg2 PDSCH/Msg4 PDSCH/PDCCH/PDCCH of Msg2/SSB cannot meet the performance requirement.

Only if 3dB loss is not considered:

Proposal 3-1z

For PUSCH for low data rate of 3 kbps with parameter set-1 for LEO-1200 operating at LOS,

- Eight sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PUSCH for low data rate of 3 kbps is unnecessary.

Proposal 4-1z

For Msg3 PUSCH with parameter set-1 for LEO-1200 operating at LOS,

- Eight sources observed that the existing specification can meet the performance requirement
- One source observed that the existing specification cannot meet the performance requirement with at least 1.5 dB gap, unless Msg3 retransmission is scheduled

RAN1 concluded that enhancement of Msg3 PUSCH is unnecessary.

Proposal 5-1z

For PUCCH format 1 with parameter set-1 for LEO-1200 operating at LOS,

- Five sources observed that the existing specification can meet the performance requirement
- One source observed that the existing specification cannot meet the performance requirement with at least 4.6 dB gap

RAN1 concluded that enhancement of PUCCH format 1 is unnecessary.

Proposal 5-2z

For PUCCH format 3 with parameter set-1 for LEO-1200 operating at LOS,

- Six sources observed that the existing specification can meet the performance requirement
- One source observed that the existing specification cannot meet the performance requirement with at least 0.6 dB gap

RAN1 concluded that enhancement of PUCCH format 3 is unnecessary.

Proposal 5-3z

For PUCCH for Msg4 HARQ-ACK with parameter set-1 for LEO-1200 operating at LOS,

- One source observed that the existing specification can meet the performance requirement
- Four sources observed that the existing specification cannot meet the performance requirement with at least 1.8 dB gap

RAN1 concluded that PUCCH for Msg4 HARQ-ACK should be enhanced.

Proposal 6-4z

For PRACH format 0 with parameter set-1 for LEO-1200 operating at LOS,

- One source observed that the existing specification can meet the performance requirement
- Eight sources observed that the existing specification cannot meet the performance requirement with at least 0.3 dB gap

For PRACH format 2 with parameter set-1 for LEO-1200 operating at LOS,

- Nine sources observed that the existing specification can meet the performance requirement
- Three sources observed that the existing specification cannot meet the performance requirement with at least 1.9 dB gap

For PRACH format B4 with parameter set-1 for LEO-1200 operating at LOS,

- Ten sources observed that the existing specification cannot meet the performance requirement with at least 1.2 dB gap

RAN1 concludes that enhancement of PRACH format is unnecessary.

Proposal 10-1z

For Msg2 PDSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated without PFD limitation,

- Two sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of Msg2 PDSCH is unnecessary, if PFD limit is not considered.

Proposal 10-2z

For Msg4 PDSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated without PFD limitation,

- Two sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of Msg4 PDSCH is unnecessary, if PFD limit is not considered.

Proposal 11-1z

For PDCCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated without PFD limitation,

- Seven sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH is unnecessary, if PFD limit is not considered.

Proposal 11-2z

For PDCCH of Msg4 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated without PFD limitation,

- One source observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH of Msg4 is unnecessary, if PFD limit is not considered.

Proposal 12-1z

For SSB with parameter set-1 for LEO-1200 operating at LOS and CNR calculated without PFD limitation,

- Three sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH is unnecessary, if PFD limit is not considered.

Proposal 7-3z

RAN1 observed that if PFD limit is considered, the existing specification for PDSCH/Msg2 PDSCH/Msg4 PDSCH/PDCCH/PDCCH of Msg2/SSB cannot meet the performance requirement.

Only if 3dB loss is considered also for VoIP:

Proposal 2-1_v3y

For PUSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Sixteen sources observed that the existing specification cannot meet the performance requirement with at least 1.3 dB gap

Alt 1: RAN1 concluded that enhancement of PUSCH for VoIP is unnecessary.

Alt 2: RAN1 concluded that enhancement of PUSCH for VoIP is difficult.

Alt 3: RAN1 concluded that PUSCH for VoIP should be enhanced.

Proposal 8-1_v2y

For PDSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Eight sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDSCH for VoIP is unnecessary, if PFD limit is not considered.

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4. Discussion

Firstly, FL would like to ask what kind of agreements are necessary. FL's thinking is that observations based on companies' inputs should be agreed to inform RAN plenary of RAN1's view and also to have alignment among companies. Then, based on the observations, we can discuss whether RAN1 should enhance for each channel or not. FL prepared proposals based on this direction below; if you have any recommendation (e.g., observation proposals are unnecessary, etc.), please feel free to share it.

Company	Comment
Samsung	Agree. We should discuss observations on performance results first and understand roughly the range of needed performance enhancements to support a scenario.
Ericsson	In light of the simulation results from many companies, showing performance gaps that are unfeasible to overcome in many cases, the scope of the study should be revisited. E.g., it should be discussed: • if satellite RF parameter Set-2 can be deprioritized • if LEO can be prioritized over GEO/MEO • if LOS being the most common case for rural environments can be prioritized • if the case with PFD limitation in DL can be deprioritized.

4.1. (Closed) LOS vs NLOS

FL found that several companies reported that NLOS environment should be de-prioritized. [3/HW, HiSi] states that LOS channel is the majority cases (larger than 90%) for UEs served by LEOs in rural scenarios. [7/vivo] raises an issue that clutter loss is defined for NLOS in 38.811 and it is over 18 dB. Besides, at least [9/MTK] [13/Pana] suggest prioritizing NLOS environment. It seems that most companies assume LOS channel in their simulations. Therefore, FL suggest the following proposal.

Proposal 1_v0

For coverage enhancement in NTN, NLOS environment is deprioritized.

Please input comment in the table below, if any.

Company	Comment
ZTE	We think reason why NLOS is deprioritized should be clarified and agreed first, e.g., too large performance gap is observed. After such an agreement, we can then discuss whether to deprioritize NLOS.
Panasonic	Agree.
Spreadtrum	Support
NTT DOCOMO	Support. We think that LOS environment would be typical for NTN.
Xiaomi	Support
vivo	Agree that NLOS should be deprioritized. Based on our simulation results, the performance gap of NLOS is far away from LOS, which would require more enhancement. Another reason is about the clutter loss (CL). As indicated in our contribution, 18.42 dB CL for 30° elevation angle, 18.17 dB CL for 20° and 19.52 dB CL for 10° (instead of 0 dB assumed in the evaluation) in rural scenarios should be considered for NLOS, which would leading to additional larger performance gap.
Samsung	Evaluation of NLOS does not seem sufficient to draw conclusions. OK to deprioritize.
OPPO	Agree with ZTE that the clarification on the reason why NLOS is deprioritized is needed in the proposal.
Baicells	Agree.
Huawei, HiSilicon	Agree
Ericsson	Agree

For offline discussion

Proposal 1_v1

For coverage enhancement in NTN, NLOS environment is deprioritized.

- RAN1 assumes that LOS environment is typical for NTN coverage enhancement.

4.2. PUSCH for VoIP

4.2.1. Observations

Companies' inputs for LOS environment can be summarized as below:

- Case 3 (LEO-1200 set 1)
  - ➢ Can the existing specification meet the performance requirement?
    - ✧ YES: [1/THALES] [5/NTPU] [7/vivo] [9/MTK] [13/Pana] [14/Xiaomi] [15/Samsung]
    - ✧ NO: [11/OPPO] [21/Apple] [23/Baicells] [24/DCM] [25/Ericsson] [3/HW, HiSi]
- Case 4 (LEO-1200 set 2)
  - ➢ Can the existing specification meet the performance requirement?
    - ✧ YES:
    - ✧ NO: [1/THALES] [4/Spreadtrum] [5/NTPU] [6/ZTE (6.07 dB)] [7/vivo (4.36dB)] [11/OPPO] [13/Pana] [14/Xiaomi] [15/Samsung] [18/Nokia, NSB] [21/Apple] [23/Baicells] [24/DCM] [25/Ericsson] [3/HW, HiSi]
- Case 6 (LEO-600 set 1)
  - ➢ Can the existing specification meet the performance requirement?
    - ✧ YES: [5/NTPU] [7/vivo] [9/MTK] [12/CATT] [11/OPPO] [13/Pana] [14/Xiaomi] [15/Samsung] [21/Apple] [23/Baicells] [25/Ericsson] [3/HW, HiSi]
    - ✧ NO: ~~[3/HW, HiSi (3.4 dB)]~~
- Case 7 (LEO-600 set 2)
  - ➢ Can the existing specification meet the performance requirement?
    - ✧ YES: [7/vivo] [9/MTK] [13/Pana] [14/Xiaomi] [15/Samsung]
    - ✧ NO: [1/THALES] [4/Spreadtrum (2.69 dB)] [11/OPPO] [18/Nokia, NSB] [19/QC] [21/Apple] [23/Baicells] [25/Ericsson] [3/HW, HiSi]

Based on the above summary, FL believes that at least 'YES' for Case 3 and Case 6 and 'NO' for Case 4. Regarding Case 7, although slightly larger number of companies show that the existing specification is insufficient, FL guesses that there are parameter/feature sets to obtain sufficient performance for UL VoIP, e.g., JCE. Therefore, the following proposal is suggested.

4.2.1.1. 1st round

Proposal 2-1_v0

On PUSCH for VoIP,

- For Case 3/6/7 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 4 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	We think for case 4 and 6, the observation can be agreed. However, for case 3 and case 7, different companies have quite diverse observations. We think clarification and alignment on the simulation assumptions are needed. After further evaluations based on aligned assumptions, the observations can then be agreed.
Panasonic	Agree with the observation.
Xiaomi	Support
vivo	A note should be included to clarify "existing specification" includes JCE which is assumed in our evaluation. Companies should check whether NTN specific updates is needed in current spec. to make JCE work in NTN.
Samsung	Agree
Lenovo	Share similar view with ZTE.
OPPO	We do not support the proposal. For case 4 and case 6, the observations of different companies can be aligned and agreed. However, for case 3 and case 7, the observations are split and even more companies (9/14) identify coverage issue on case 7. Besides, if the feature introduced in R17 CovEnh, e.g., JCE, is taken as baseline, further evaluation is needed.
Baicells	Agree on Case 4 and Case 6. For further discussion on Case 3/7.
Huawei, HiSilicon	For case 6 and case 4, the observation is OK. For Case 3/4/7 in LOS environment, we observed that the existing specification can't meet the performance requirement
Ericsson	Our simulations do not confirm that case 3 and 7 meets the target. We agree that case 6 meets target requirement.

For offline discussion

Proposal 2-1_v1a

On PUSCH for VoIP,

- For Case 3/6/7 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 4 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement

Proposal 2-1_v1b

On PUSCH for VoIP,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 4 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 3 in LOS environment,
    - Seven sources observed that the existing specification can meet the performance requirement
    - Six sources observed that the existing specification cannot meet the performance requirement
- For Case 7 in LOS environment,
    - Five sources observed that the existing specification can meet the performance requirement
    - Nine sources observed that the existing specification cannot meet the performance requirement

4.2.1.2. (Open) 2nd round

Based on the proposal 15-2, CNR is calculated as follows according to companies' inputs.

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP [dBm]	RX: G/T [dB/T]	No. of PRBs	Bandwidth [MHz]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	18.0	1.1	1	0.18	164.5	0.1	3.0	2.2	3.0	0.0	-7.6
								2	0.36							-10.6
								3	0.54							-12.4
								4	0.72							-13.6
								6	1.08							-15.4

[1/THALES]: (Required SNR) – (CNR) = (-14.2) – (-13.6) = -0.6 dB

[3/HW, HiSi]: (Required SNR) – (CNR) = (-8.0) – (-10.6) = 2.6 dB

[4/Spreadtrum]: (Required SNR) – (CNR) = (-10.3) – (-10.6) = 0.3 dB

[5/NTPU]: (Required SNR) – (CNR) = (-8.6) – (-7.6) = -1.0 dB

[6/ZTE]: (Required SNR) – (CNR) = (-7.6) – (-10.6) = 3.0 dB

[7/vivo]: (Required SNR) – (CNR) = (-12.3) – (-10.6) = -1.7 dB

[11/OPPO]: (Required SNR) – (CNR) = (-5.4) – (-7.6) = 2.2 dB

[12/CATT]: (Required SNR) – (CNR) = (-12.0) – (-15.4) = 3.4 dB

[13/Pana]: (Required SNR) – (CNR) = (-8.4) – (-7.6) = -0.8 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-8.4) – (-12.4) = 4.0 dB

[18/Nokia, NSB]: (Required SNR) – (CNR) = (-5.0) – (-13.6) = 8.6 dB

[19/QC]: (Required SNR) – (CNR) = (-7.6) – (-7.6) = 0.0 dB

[21/Apple]: (Required SNR) – (CNR) = (-9.3) – (-12.4) = 3.1 dB

[23/Baicells]: (Required SNR) – (CNR) = (-8.3) – (-10.6) = 2.3 dB

[24/DCM]: (Required SNR) – (CNR) = (-6.0) – (-10.6) = 4.6 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-6.3) – (-10.6) = 4.3 dB

Proposal 2-1_v2

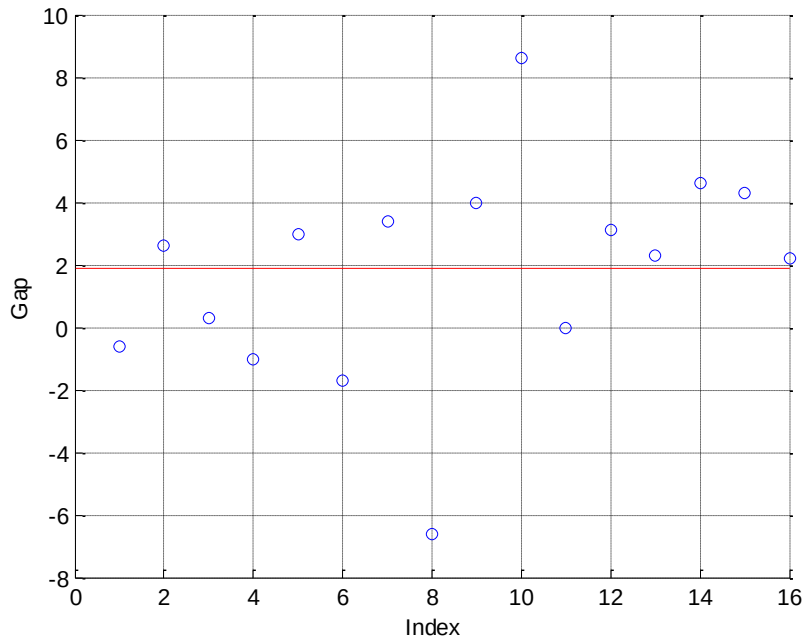
For PUSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS,

- Six sources observed that the existing specification can meet the performance requirement
- Nine sources observed that the existing specification cannot meet the performance requirement with at least 0.3 dB gap

RAN1 concluded that enhancement of PUSCH for VoIP is unnecessary.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment
OPPO	Ok in principle	We also provided simulation results and should be captured as one source. We agree that further enhancement for VOIP for PUSCH may be difficult, thus, we can make a conclusion to say: **Proposal 2-1_v2-OPPO** For PUSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS, • Six sources observed that the existing specification can meet the performance requirement • ~~Nine~~Ten sources observed that the existing specification cannot meet the performance requirement with at least 0.3 dB gap RAN1 concluded that enhancement of PUSCH for VoIP is difficult ~~unnecessary~~.
OPPO2		Besides, we provide the required SNR and CNR for capturing our simulation results as follows: [11/OPPO]: (Required SNR) – (CNR) = (-5.4) – (-7.6) = 2.2 dB
Apple	Fine with the proposal	Although our simulations show there is a gap for PUSCH VoIP, our simulation assumption is no joint channel estimation. Considering the gain from joint channel estimation (supported in existing specification), we are fine with the proposal. By the way, our result is (-9.3)-(-12.4)=3.1 dB.

Baicells2		 As illustrated in the figure above, for link budget gaps from 16 sources (with input from OPPO2 and modification by Apple), discarding the best one and the worst one, the average value is 1.89dB. Therefore, we think the uplink budget for LEO-1200 set1 VoIP needs some enhancement.
ZTE	No	More than half sources observed that existing specification cannot meet the performance requirement. We don't think it can be directly concluded that enhancement is unnecessary just based on the observations.

Proposal 2-1_v3

For PUSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS,

- Five sources observed that the existing specification can meet the performance requirement
- Eleven sources observed that the existing specification cannot meet the performance requirement with at least 0.3 dB gap

Alt 1: RAN1 concluded that enhancement of PUSCH for VoIP is unnecessary.

Alt 2: RAN1 concluded that enhancement of PUSCH for VoIP is difficult.

Alt 3: RAN1 concluded that PUSCH for VoIP should be enhanced.

4.2.2. (Closed) Whether to enhance

From the above observation/proposal, it is clear that if Case 4 (LEO-1200 set 2) should be considered for VoIP, PUSCH enhancement is necessary. It seems that at least [1/THALES] [3/HW, HiSi] [4/Spreadtrum] [6/ZTE] [14/Xiaomi] [18/Nokia, NSB] [23/Baicells] [24/DCM] are positive to do enhancement of PUSCH for VoIP.

4.2.2.1. 1st round

Proposal 2-2_v0

For NTN coverage enhancement, RAN1 observed that PUSCH should be enhanced for VoIP.

- VoIP is supported for Case 3/4/6/7.

Please input comment in the table below, if any.

Company	Comment
ZTE	Support to enhance PUSCH for VoIP. VoIP may be supported for Case 3 and 6 with higher priority. However, we have shown previously that the performance for case 3 (LEO-1200, set 1) cannot be considered satisfied for certain elevation angles with 1T1R assumption. Even if we deprioritize case 4, enhancement is still preferred to mitigate the performance gap for case 3.
Panasonic	It should be discussed whether both satellite parameter sets should be supported. Our view is that parameter set 2 (i.e. case 4 and 7) can be deprioritized for VoIP.
Spreadtrum	Support to enhance PUSCH for VoIP.
NTT DOCOMO	Support to enhance PUSCH for VoIP. Discussion is needed on whether to support both parameter set 1 and 2.
Xiaomi	Support to enhance PUSCH for VoIP.
vivo	To conclude which scenarios should support VoIP, we can not only look at PUSCH, random access is also required. In our view, making JCE work in NTN is enough in our view according to the observations from the evaluation of VoNR on PUSCH. Case 4, i.e. LEO-1200 set 2, should be deprioritized. In our evaluation, 4.36dB performance gap is required to support PUSCH VoIP for LEO-1200 set-2 satellites even with DMRS bundling enabled. This performance gap can be hardly compensated due to 20ms TTI requirement for a voice packet.
Samsung	We prefer to consider only case 3/6/7 except for case 4, which is slightly similar to PUSCH for low-data rate service.
Lenovo	Support. Fine to discuss the parameter set with high priority.

OPPO	The performance gap is significantly large for case 7 and the number of repetitions is limited to 20 for 15kHz SCS due to 20ms data arriving interval, so we can firstly discuss the scenarios with higher priority, as well as target elevation angles for VoIP service.
MediaTek	We prefer only cases 3/6/7 for PUSCH for VoIP
Baicells	Support to enhance PUSCH for VoIP.
Huawei, HiSilicon	We are positive to enhance PUSCH for VoIP. We also think the case 4, i.e. LEO-1200 Set2 should be deprioritized, where about 9dB gap is observed. We prefer to focus on LEO-600, and LEO-1200 set1 cases.
Ericsson	We do not agree. Overall, we think RAN1 should focus on LEO-600 for set 1 which is the most attractive deployment option for handheld connectivity. For this case optimization for PUSCH is not needed.

Proposal 2-2_v1a

For NTN coverage enhancement, ~~RAN1 observed that PUSCH should be enhanced for VoIP.~~ VoIP is supported for Case 3/4/6/7.

- ~~VoIP is supported for Case 3/4/6/7.~~ RAN1 observed that PUSCH should be enhanced for VoIP

4.3. PUSCH for low-data rate service

4.3.1. Observations

Companies' inputs for LOS environment can be summarized as below:

<u>For 3kbps</u>

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo]
    - NO: [6/ZTE] [11/OPPO] [14/Xiaomi] [18/Nokia, NSB] [21/Apple] [23/Baicells] [24/DCM] [25/Ericsson]
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [6/ZTE] [7/vivo] [11/OPPO] [14/Xiaomi] [18/Nokia, NSB] [21/Apple] [23/Baicells] [24/DCM] [25/Ericsson]
- Case 5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?

        - YES: [7/vivo]
        - NO: [6/ZTE] [11/OPPO] [13/Pana] [14/Xiaomi] [21/Apple] [23/Baicells] [19/QC] [25/Ericsson]
- Case 8 (LEO-600 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [11/OPPO] [12/CATT(?)] [13/Pana] [14/Xiaomi] [19/QC] [21/Apple] [7/vivo]
        - NO: [23/Baicells] [25/Ericsson]
- Case 9 (MEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo] [13/Pana]
        - NO: [23/Baicells] [25/Ericsson]
- Case 10 (MEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [7/vivo] [13/Pana] [23/Baicells] [25/Ericsson]

<u>For 100kbps</u>

- Case 1 (GEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [7/vivo] [13/Pana] [14/Xiaomi] [21/Apple] [23/Baicells]
- Case 2 (GEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [4/Spreadtrum] [7/vivo] [13/Pana] [14/Xiaomi] [21/Apple] [23/Baicells]
- Case 5 (LEO-1200 set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [4/Spreadtrum] [4/Spreadtrum] [7/vivo] [13/Pana] [14/Xiaomi] [21/Apple] [23/Baicells]
- Case 8 (LEO-600 set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [7/vivo] [13/Pana] [14/Xiaomi] [21/Apple] [23/Baicells]
- Case 9 (MEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES:

- NO: [7/vivo] [13/Pana] [23/Baicells]

- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [23/Baicells]

Based on the above summary, FL believes that it is straightforward to conclude as UL 100kbps cannot be achieved in any cases. Regarding 3kbps, at least Case 2/5/8/10 can be concluded the majority view. For Case 1/9, only one or two companies reported as 'YES', but at the same time, we can see the same number of or more companies reported as 'NO'. In this case, FL recommends capturing both opinions as a kind of a RAN1 observation. Therefore, the following proposal is suggested. Alternatively, we can decide to take either by discussion.

4.3.1.1. 1st round

Proposal 3-1_v0

On PUSCH for low-data rate service with 3kbps,

- For Case 8 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/5/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
  - One source observed that the existing specification can meet the performance requirement
  - Seven sources observed that the existing specification cannot meet the performance requirement
- For Case 9 in LOS environment,
  - Two sources observed that the existing specification can meet the performance requirement
  - Two sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Support
Panasonic	Agree with the observation.
Spreadtrum	Support
NTT DOCOMO	Support

Xiaomi	Support
vivo	For case 5, with JCE, it can be supported. A conclusion made based on majority companies should be on the condition of assumptions used by the majority companies, otherwise the conclusion is not clear. A note should be included to clarify "existing specification" includes JCE or does not include JCE.
Samsung	We would like to see observations for all cases ("LEO-1200 set 1" and "LEO-600 set 1" are missing from the list below) and with same level of details in order to be able to (de)-prioritize some cases.
Lenovo	Support.
OPPO	We support the proposal.
Baicells	Basically agree. But we also need clarification on whether beam edge loss should be considered as an evaluation assumption. In #109-e agreements, it is stated that: "For coverage performance evaluation, the following elevation angle is assumed.....these values are elevation angles at the edge of the edge beam." We understand that at the edge of the edge beam, the link budget is 3dB less than the beam center for both DL and UL. In our evaluation, beam center and beam edge are considered respectively, which may derive different conclusion for some of these evaluation cases, eg. 3kbps PUSCH case 8.
Hughes/Echo Star	Support the observation
Ericsson	Our results confirm that case 8 meets the target. The other cases do not.

Proposal 3-2_v0

On PUSCH for low-data rate service with 100kbps,

- For Case 1/2/5/8/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Support
Panasonic	Agree with the observation.

Spreadtrum	Support
NTT DOCOMO	Support
Xiaomi	Support
vivo	Agree.
Samsung	We would like to suggest considering all cases ("LEO-1200 set 1" and "LEO-600 set 1") instead of agreeing cases by case. If all cases cannot meet the requirement, we can add all cases in the proposal. Otherwise, we can identify which cases meet the requirement or doesn't meet.
Lenovo	Support.
OPPO	We support the proposal in principle, and 10kbps can be achieved for case8 in our evaluation.
Baicells	Agree.
Huawei, HiSilicon	Agree.
Ericsson	Agree

For offline discussion

Proposal 3-1_v1 (no update)

On PUSCH for low-data rate service with 3kbps,

- For Case 8 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/5/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - Seven sources observed that the existing specification cannot meet the performance requirement
- For Case 9 in LOS environment,
    - Two sources observed that the existing specification can meet the performance requirement
    - Two sources observed that the existing specification cannot meet the performance requirement

Proposal 3-2_v1 (no update)

On PUSCH for low-data rate service with 100kbps,

- For Case 1/2/5/8/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement

4.3.1.2. (Open) 2nd round

Based on the proposal 15-2, CNR is calculated as follows according to companies' inputs.

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP [dBm]	RX: G/T [dB/T]	No. of PRBs	Bandwidth [MHz]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	18.0	1.1	1	0.18	164.5	0.1	3.0	2.2	3.0	3.0	-10.6
								2	0.36							-13.6
								3	0.54							-15.4
								4	0.72							-16.6
								6	1.08							-18.4

[6/ZTE]: (Required SNR) – (CNR) = (-11.0) – (-10.6) = -0.4 dB

[7/vivo]: (Required SNR) – (CNR) = (-18.2) – (-13.6) = -4.6 dB

[13/Pana]: (Required SNR) – (CNR) = (-14.3) – (-10.6) = -3.7 dB

[11/OPPO]: (Required SNR) – (CNR) = (-11.9) – (-10.6) = -1.3 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-16.5) – (-15.4) = -1.1 dB

[21/Apple]: (Required SNR) – (CNR) = (-14.5) – (-16.6) = 2.1 dB

[23/Baicells]: (Required SNR) – (CNR) = (-12.3) – (-13.6) = 1.3 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-10.7) – (-13.6) = 2.9 dB

Proposal 3-1_v2

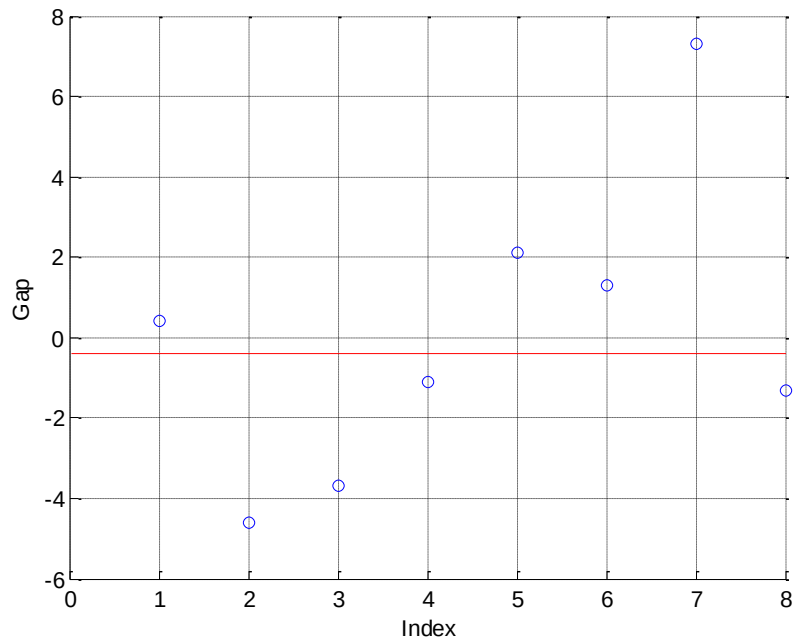
For PUSCH for low data rate of 3 kbps with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Four sources observed that the existing specification can meet the performance requirement
- Three sources observed that the existing specification cannot meet the performance requirement with at least 1.3 dB gap

RAN1 concluded that enhancement of PUSCH for low data rate of 3 kbps is unnecessary.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

OPPO	OK with modification	Our simulation results are not captured in the list. We are appreciated if our simulation can be captured as one source.
OPPO2		Besides, we also provide the required SNR and CNR for capturing our simulation results as follows: [11/OPPO]: (Required SNR) – (CNR) = (-11.9) – (-10.6) = -1.3 dB
Apple	Fine with the proposal	Although our simulations show there is a gap for PUSCH 3 kbps, our simulation assumption is no joint channel estimation. Considering the gain from joint channel estimation (supported in existing specification), we are fine with the proposal. Also, we are not sure if the additional loss of 3 dB needs to be included in the link budget analysis.
Baicells2		 (including input from OPPO2) As illustrated in the figure above, discarding the best one and the worst one, the average value is -0.38dB. Therefore, we agree that the uplink budget for LEO-1200 set1 3kbps does not needs enhancement.
ZTE	No	Our simulation is based on 2RB. If the 3dB additional loss is considered, the gap should be: [6/ZTE]: (Required SNR) – (CNR) = (-11.0) – (-13.6) = 2.6 dB Moreover, we think for low data rate, set-2 can be considered since lower SNR is required compared with VoIP. No need to restrict the low data rate service working only in best case. And with assumption of 3dB additional loss, the observations do not clearly show that enhancement is not needed.

Proposal 3-1_v3

For PUSCH for low data rate of 3 kbps with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Three sources observed that the existing specification cannot meet the performance requirement with at least 1.3 dB gap

RAN1 concluded that enhancement of PUSCH for low data rate of 3 kbps is unnecessary.

4.3.2. (Closed) Whether to enhance

For 3kbps, only Case 8 can support this data rate and the remaining cases cannot supported or may not be supported. FL found that at least [6/ZTE] [7/vivo] [14/Xiaomi] [18/Nokia, NSB] [23/Baicells] [24/DCM] are proposing enhancement. Besides, [3/HW, HiSi] [7/vivo] [9/MTK] [12/CATT] [13/Pana] [18/Nokia, NSB] suggest focusing on set 1 due to large gap for set 2.

For 100kbps, any cases cannot support this data rate and several companies reported that performance gap is not small. [7/vivo] [14/Xiaomi (?)] [13/Pana] suggests deprioritizing this data rate.

4.3.2.1. 1st round

Proposal 3-3_v0

For NTN coverage enhancement, RAN1 observed that PUSCH should be enhanced for low-data rate with 3kpbs.

- UL low-data rate service with 3kbps is supported for Case 1/9
- Parameter set 2 (i.e., Case 2/5/8/10) is deprioritized.

Proposal 3-4_v0

For NTN coverage enhancement, down-select from the following options for PUSCH for low-data rate with 100kbps.

- Option 1: PUSCH for low-data rate with 100kpbs is deprioritized
- Option 2: PUSCH should be enhanced for low-data rate with 100kbps
    - Option 2-1: UL low-data rate service with 100kbps is supported for Case 1/9
        - Parameter set 2 (i.e., Case 2/5/8/10) is deprioritized.
    - Option 2-2: UL low-data rate service with 100kbps is supported for Case 5/8
        - GEO/MEO (i.e., Case 1/2/9/10) are deprioritized.

Please input comment in the table below, if any.

Company	Comment
ZTE	For proposal 3-3, support. For proposal 3-4, support option 1. It is not expected to enhance the spec to support such high data rate.
Panasonic	On PUSCH 3kbps, agree with Proposal 3-3_v0. On PUSCH 100kbps, agree with Option 1 in Proposal 3-4_v0.
Spreadtrum	Support both Proposal 3-3 and Proposal 3-4.
NTT DOCOMO	Proposal 3-3_v0: Support Proposal 3-4_v0: We prefer Option 1. It seems less practical to achieve such high data rate.
Xiaomi	For proposal 3-3, support. For proposal 3-4, support option 1.
vivo	For proposal 3-3, support. For proposal 3-4, agree with option 1. 100kbps data rate is 10 times higher than the VoNR and should be deprioritized.
Samsung	For proposal 3-3_v0, why case 8 is deprioritized? This is because this case already meets the requirement? For proposal 3-4_v0, we slightly prefer option 1because it seems that all cases cannot meet the requirement with large gap. However, we are open to discuss possible enhancement according to final observation that we will discuss.
Lenovo	Support proposal 3-3. For proposal 3-4, support option 1.
OPPO	For proposal 3-3, the date rate will further decrease with the increasing number of repetitions and the performance gain is limited when the number of repetitions is larger than 32, so whether case 1/9 is supported should be further discussed. In addition, LEO600/1200 set2 shows better CNR performance than GEO set1, i.e.., case 1. Therefore, we can firstly discuss the scenarios with higher priority For proposal 3-4, we support option1.
MediaTek	Support proposal 3-3: Support Proposal 3-4: Support Option 1
Baicells	On Proposal 3-3_v0: We suggest deprioritize case 2/10 (GEO-set2/MEO-set2) which have the largest performance gap. On Proposal 3-4_v0: Option1

Huawei, HiSilicon	For proposal 3-3, support. For proposal 3-4, we support option 1.
Hughes/Echo Star	Proposal 3-3: Support
Ericsson	Handheld UE connectivity to a GEO or MEO satellite is not feasible based on our findings, and we do not agree to enhance PUSCH for case 1/9. We support option 1.

4.4. Msg3 PUSCH

4.4.1. Observations

Companies' inputs for LOS environment can be summarized as below:

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo (w/ reTX)]
    - NO: [6/ZTE] [11/OPPO] [14/Xiaomi] [21/Apple] [24/DCM] [25/Ericsson][3/HW, HiSi]
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [6/ZTE] [7/vivo] [11/OPPO] [14/Xiaomi] [21/Apple] [24/DCM] [25/Ericsson] [3/HW, HiSi]
- Case 3 (LEO-1200 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [1/THALES] [7/vivo] [11/OPPO] [12/CATT] [13/Pana] [14/Xiaomi] [21/Apple] [24/DCM] [3/HW, HiSi]
    - NO: [25/Ericsson]
- Case 4/5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo (w/ reTX)]
    - NO: [1/THALES] [6/ZTE] [11/OPPO] [13/Pana] [14/Xiaomi] [19/QC] [21/Apple] [24/DCM] [25/Ericsson] [3/HW, HiSi]
- Case 6 (LEO-600 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [12/CATT] [13/Pana] [14/Xiaomi] [21/Apple] [25/Ericsson] [3/HW, HiSi]

- NO:

- Case 7/8 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [1/THALES] [7/vivo] [11/OPPO] [12/CATT] [13/Pana] [14/Xiaomi] [19/QC] [21/Apple] [3/HW, HiSi]
    - NO: [25/Ericsson]
- Case 9 (MEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo (w/ reTX)] ~~[13/Pana]~~
    - NO: [25/Ericsson] [13/Pana]
- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [25/Ericsson]

Based on the above summary, FL found that the existing Msg3 cannot meet the requirement in Case 2/10. Case 1/4/5 faces similar situation, but [7/vivo] argues that Msg retransmissions can solve the performance limitation with max 16 repetitions. This aspect would be true, so the corresponding observation can be made. It would be clear that Case 3/6/7/8 can be 'YES' as answer to the question. For Case 9, observations from three companies seem split; the same way as in the previous section is used here.

4.4.1.1. 1st round

Proposal 4-1_v0

For Msg3 PUSCH,

- For Case 3/6/7/8 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1/4/5 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement, unless Msg3 retransmission is not scheduled
- For Case 9 in LOS environment,
  - One source observed that the existing specification can meet the performance requirement
  - One source observed that the existing specification cannot meet the performance requirement
  - One source observed that the existing specification cannot meet the performance requirement, unless Msg3 retransmission is not scheduled

Please input comment in the table below, if any.

Company	Comment
ZTE	Basically support. But for case 1/4/5, the observation seems should be "can meet the performance requirement, unless Msg3 retransmission is not scheduled"?
Panasonic	For Case 9 (MEO), we updated company's position because our result for msg.3 was with JCE although JCE is not supported for msg3 in Rel.17. Our result without JCE does not meet the performance requirement for MEO set1. Please delete "One source observed that the existing specification can meet the performance requirement" for Case 9 in the proposal 4-1.
NTT DOCOMO	Support
Xiaomi	Support
vivo	Case 2/10 can also work with enough number of retransmissions, which should treated in the same way as Case 1/4/5. Therefore, we do not think any enhancement for Msg3 is needed. Note that in the 3rd bullet, it seems the last "not" should be removed, as is pointed out by ZTE as well.
Samsung	It seems unclear what repetition value are assumed for observations. So, before making a conclusion, it should be clarified first.
Lenovo	Support. Agree with ZTE and VIVO.
OPPO	We support the proposal.
Huawei, HiSlicon	We are basically fine. However, for the third bullet, it seems it should be "For Case 1/4/5 in LOS environment, RAN1 observed that the existing specification can~~not~~ meet the performance requirement, unless Msg3 retransmission is not scheduled"
Ericsson	Agree

For offline discussion

Proposal 4-1_v1

For Msg3 PUSCH,

- For Case 3/6/7/8 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- ~~For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement~~
- For Case 1/2/4/5/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement, unless Msg3 retransmission is ~~not~~ scheduled
- For Case 9 in LOS environment,

- ~~One source observed that the existing specification can meet the performance requirement~~
- ~~One~~ Two sources observed that the existing specification cannot meet the performance requirement
- One source observed that the existing specification cannot meet the performance requirement, unless Msg3 retransmission is ~~not~~ scheduled

4.4.1.2. (Open) 2nd round

Based on the proposal 15-2, CNR is calculated as follows according to companies' inputs.

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP [dBm]	RX: G/T [dB/T]	No. of PRBs	Bandwidth [MHz]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	18.0	1.1	2	0.36	164.5	0.1	3.0	2.2	3.0	3.0	-13.6

For 10% iBLER, the following performance gap can be observed.

[1/THALES]: (Required SNR) – (CNR) = (-14.0) – (-13.6) = -0.4 dB

[3/HW, HiSi]: (Required SNR) – (CNR) = (-12.1) – (-13.6) = 1.5 dB

[6/ZTE]: (Required SNR) – (CNR) = (-11.8) – (-13.6) = 1.8 dB

[7/vivo]: (Required SNR) – (CNR) = (-13.1) – (-13.6) = 0.5 dB

Note: [7/vivo] considers 2% iBLER

Note: [7/vivo] argues that Msg retransmissions can solve the performance limitation with max 16 repetitions

[11/OPPO]: (Required SNR) – (CNR) = (-11.8) – (-13.6) = 1.8 dB

[12/CATT]: (Required SNR) – (CNR) = (-14.0) – (-13.6) = -0.4 dB

[13/Pana]: (Required SNR) – (CNR) = (-15.0) – (-13.6) = -1.4 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-10.2) – (-13.6) = 3.4 dB

Note: [14/Xiaomi] considers 1% iBLER

[21/Apple]: (Required SNR) – (CNR) = (-11.8) – (-13.6) = 1.8 dB

[24/DCM]: (Required SNR) – (CNR) = (-11.3) – (-13.6) = 2.3 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-9.1) – (-13.6) = 4.5 dB

Proposal 4-1_v2

For Msg3 PUSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Three sources observed that the existing specification can meet the performance requirement

- Six sources observed that the existing specification cannot meet the performance requirement with at least 1.5 dB gap, unless Msg3 retransmission is scheduled

From RAN1 perspective, enhancement of Msg3 PUSCH is unnecessary.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment
OPPO	No	I think majority companies who find that the gap is below 2.3 dB. It is not clear why the enhancement is not necessary. To us, the enhancement is doable and needed. We suggest the following alternative proposal **Proposal 4-1_v2-OPPO** For Msg3 PUSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB, • Three sources observed that the existing specification can meet the performance requirement • Five sources observed that the existing specification cannot meet the performance requirement with at least 1.5 dB gap, unless Msg3 retransmission is scheduled From RAN1 perspective, enhancement of Msg3 PUSCH to close the gap is feasible ~~unnecessary~~.
OPPO2		Besides, we provide the required SNR and CNR for capturing our simulation results as follows: [11/OPPO]: (Required SNR) – (CNR) = (-11.8) – (-13.6) = 1.8 dB
Apple		We are not sure if the additional loss of 3 dB needs to be included in the link budget analysis. Without 3 dB of additional loss, our simulations show the existing specification can meet the performance requirement. With 3 dB of additional loss, our simulations show the existing specification cannot meet the performance requirement.
ZTE	No	We have simulated this case but not captured. Our simulation result is [6/ZTE]: (Required SNR) – (CNR) = (-11.8) – (-13.6) = 1.8 dB Although retransmission of Msg3 may be able to mitigate the performance gap, it will introduce larger access delay. Therefore, direct enhancement on Msg3 can be considered to avoid the delay caused by retransmission.

Proposal 4-1_v3

For Msg3 PUSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Three sources observed that the existing specification can meet the performance requirement

- Five sources observed that the existing specification cannot meet the performance requirement with at least 1.5 dB gap, unless Msg3 retransmission is scheduled

Alt 1: From RAN1 perspective, enhancement of Msg3 PUSCH is unnecessary.

Alt 2: RAN1 concluded that Msg3 PUSCH should be enhanced.

4.5. PUCCH / Msg4 PUCCH

4.5.1. Observations

Companies' inputs for LOS environment can be summarized as below:

PUCCH format 1

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [13/Pana] [14/Xiaomi]
    - NO: [7/vivo] [15/Samsung] [24/DCM] [25/Ericsson] [3/HW, HiSi]
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [14/Xiaomi] [15/Samsung] [24/DCM] [25/Ericsson] [3/HW, HiSi]
- Case 3 (LEO-1200 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [13/Pana] [14/Xiaomi] [15/Samsung] [24/DCM] [3/HW, HiSi]
    - NO: [25/Ericsson]
- Case 4/5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [13/Pana] [14/Xiaomi] [15/Samsung]
    - NO: [7/vivo] [24/DCM] [25/Ericsson] [3/HW, HiSi]
- Case 6 (LEO-600 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [13/Pana] [14/Xiaomi] [15/Samsung] [25/Ericsson] [3/HW, HiSi]
    - NO: [25/Ericsson]
- Case 7/8 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [13/Pana] [14/Xiaomi] [15/Samsung] [3/HW, HiSi]
    - NO: [25/Ericsson]

- Case 9 (MEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [13/Pana] [15/Samsung]
    - NO: [25/Ericsson]
- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [15/Samsung] [25/Ericsson]

PUCCH format 3

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [14/Xiaomi] [15/Samsung] [21/Apple] [25/Ericsson][3/HW, HiSi]
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [14/Xiaomi] [15/Samsung] [21/Apple] [25/Ericsson] [3/HW, HiSi]
- Case 3 (LEO-1200 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [12/CATT] [13/Pana] [14/Xiaomi] [15/Samsung] [21/Apple] [25/Ericsson] [3/HW, HiSi]
    - NO: [7/vivo]
- Case 4/5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [14/Xiaomi]
    - NO: [7/vivo] [13/Pana] [15/Samsung] [21/Apple] [25/Ericsson] [3/HW, HiSi]
- Case 6 (LEO-600 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [12/CATT] [13/Pana] [14/Xiaomi] [15/Samsung] [21/Apple] [25/Ericsson] [3/HW, HiSi]
    - NO:
- Case 7/8 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [12/CATT] [13/Pana] [14/Xiaomi] [15/Samsung] [21/Apple] [25/Ericsson] [3/HW, HiSi]
    - NO: [7/vivo]

- Case 9 (MEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [12/CATT] [13/Pana]
    - NO: [7/vivo] [15/Samsung] [25/Ericsson]
- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [15/Samsung] [25/Ericsson]

<u>Msg4 PUCCH</u>

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson][3/HW, HiSi]
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson] [3/HW, HiSi]
- Case 3 (LEO-1200 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo]
    - NO: [11/OPPO] [21/Apple] [25/Ericsson] [3/HW, HiSi]
- Case 4/5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson] [3/HW, HiSi]
- Case 6 (LEO-600 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
    - NO: [3/HW, HiSi]
- Case 7/8 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson] [3/HW, HiSi]
- Case 9 (MEO set 1)

- Can the existing specification meet the performance requirement?
  - YES:
  - NO: [7/vivo] [25/Ericsson]

- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [25/Ericsson]

Based on the above summary, FL has the following observations.

Firstly, for PUCCH format 1 with 2 bits, situation is clear except for Case 1/4/5. For these cases, the same approach as in the previous sections is suggested. Alternatively, we can decide either by discussion.

Secondly, for PUCCH format 3 with 11 bits, also situation is clear except for Case 4/5/9. The same approach is suggested.

Thirdly, for Msg4 HARQ-ACK, also situation is clear except for Case 3. The same approach is suggested.

4.5.1.1. 1st round

Proposal 5-1_v0

For PUCCH format 1 with 2 bits,

- For Case 3/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
  - Two sources observed that the existing specification can meet the performance requirement
  - Four sources observed that the existing specification cannot meet the performance requirement
- For Case 4/5 in LOS environment,
  - Three sources observed that the existing specification can meet the performance requirement
  - Three sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal.
Panasonic	Agree with the observation.

NTT DOCOMO	Support
vivo	Existing specification here means without JCE in our evaluation which should be noted.
Lenovo	Support.
OPPO	We support the proposal.

Huawei, HiSilicon	Considering our input, we suggest the following revisions:
	• For Case 1 in LOS environment,
	  ○ Two sources observed that the existing specification can meet the performance requirement
	  ○ ~~Four~~ Five sources observed that the existing specification cannot meet the performance requirement
	• For Case 4/5 in LOS environment,
	  ○ Three sources observed that the existing specification can meet the performance requirement
	  ○ ~~Three~~ Four sources observed that the existing specification cannot meet the performance requirement

Ericsson	Our simulations confirms that at least the important case 6 meets the requirements.

Proposal 5-2_v0

For PUCCH format 3 with 11 bits,

- For Case 3/6/7/8 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 1/2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 4/5 in LOS environment,
  - One source observed that the existing specification can meet the performance requirement
  - Five sources observed that the existing specification cannot meet the performance requirement
- For Case 9 in LOS environment,
  - Two sources observed that the existing specification can meet the performance requirement
  - Three sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal.
Panasonic	Agree with the observation.
vivo	Existing specification here means without JCE in our evaluation which should be noted.
Lenovo	Support.
OPPO	We support the proposal.

Huawei, HiSilicon	Considering our input, we suggest the following revisions:
	• For Case 4/5 in LOS environment,
	  ○ One source observed that the existing specification can meet the performance requirement
	  ○ ~~Five~~ Six sources observed that the existing specification cannot meet the performance requirement

Ericsson	Agree

Proposal 5-3_v0

For PUCCH for Msg4 HARQ-ACK,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 1/2/4/5/7/8/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 3 in LOS environment,
  - One source observed that the existing specification can meet the performance requirement
  - Three sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal.
Panasonic	Agree with the observation.

NTT DOCOMO	Support
vivo	Fine.
Lenovo	Support.
OPPO	We support the proposal.

Huawei, HiSilicon	For Case6, we observed a 0.8dB coverage gap, which is marginal.
	
	Considering our inputs, we propose the following revisions:
	
	• For Case 3 in LOS environment,
	  ○ One source observed that the existing specification can meet the performance requirement
	  ○ ~~Three~~ Four sources observed that the existing specification cannot meet the performance requirement

Ericsson	Agree

For offline discussion

Proposal 5-1_v1 (no update)

For PUCCH format 1 with 2 bits,

- For Case 3/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
  - Two sources observed that the existing specification can meet the performance requirement
  - Four sources observed that the existing specification cannot meet the performance requirement
- For Case 4/5 in LOS environment,
  - Three sources observed that the existing specification can meet the performance requirement
  - Three sources observed that the existing specification cannot meet the performance requirement

Proposal 5-2_v1 (no update)

For PUCCH format 3 with 11 bits,

- For Case 3/6/7/8 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 1/2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 4/5 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - Five sources observed that the existing specification cannot meet the performance requirement
- For Case 9 in LOS environment,
    - Two sources observed that the existing specification can meet the performance requirement
    - Three sources observed that the existing specification cannot meet the performance requirement

Proposal 5-3_v1 (no update)

For PUCCH for Msg4 HARQ-ACK,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 1/2/4/5/7/8/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 3 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - Three sources observed that the existing specification cannot meet the performance requirement

4.5.1.2. (Open) 2nd round

Based on the proposal 15-2, CNR is calculated as follows according to companies' inputs.

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP [dBm]	RX: G/T [dB/T]	No. of PRBs	Bandwidth [MHz]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	18.0	1.1	1	0.18	164.5	0.1	3.0	2.2	3.0	3.0	-10.6

The following performance gap can be observed.

<u>For PUCCH format 1</u>

[3/HW, HiSi]: (Required SNR) – (CNR) = (-9.0) – (-10.6) = 1.6 dB

[7/vivo]: (Required SNR) – (CNR) = (-12.5) – (-10.6) = -1.9 dB

[13/Pana]: (Required SNR) – (CNR) = (-15.3) – (-10.6) = -4.7 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-16.4) – (-10.6) = -5.8 dB

[24/DCM]: (Required SNR) – (CNR) = (-8.3) – (-10.6) = 2.3 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-3) – (-10.6) = 7.6 dB

For PUCCH format 3

[3/HW, HiSi]: (Required SNR) – (CNR) = (-8.2) – (-10.6) = 2.4 dB

[7/vivo]: (Required SNR) – (CNR) = (-7.0) – (-10.6) = 3.6 dB

[12/CATT]: (Required SNR) – (CNR) = (-12.5) – (-10.6) = -1.9 dB

[13/Pana]: (Required SNR) – (CNR) = (-12.6) – (-10.6) = -2.0 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-13.7) – (-10.6) = -3.1 dB

[21/Apple]: (Required SNR) – (CNR) = (-10.8) – (-10.6) = -0.2 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-11.0) – (-10.6) = 0.6 dB

For Msg4 PUCCH

[3/HW, HiSi]: (Required SNR) – (CNR) = (-1.4) – (-10.6) = 9.2 dB

[7/vivo]: (Required SNR) – (CNR) = (-7.8) – (-10.6) = 2.8 dB

[11/OPPO]: (Required SNR) – (CNR) = (-3.9) – (-10.6) = 6.7 dB

[21/Apple]: (Required SNR) – (CNR) = (-5.8) – (-10.6) = 4.8 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-3.9) – (-10.6) = 6.7 dB

Proposal 5-1_v2

For PUCCH format 1 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Three sources observed that the existing specification can meet the performance requirement
- Three sources observed that the existing specification cannot meet the performance requirement with at least 1.6 dB gap

RAN1 concluded that enhancement of PUCCH format 1 is unnecessary.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment
Apple	Fine with the proposal	

Proposal 5-2_v2

For PUCCH format 3 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Two sources observed that the existing specification cannot meet the performance requirement with at least 2.4 dB gap

RAN1 concluded that enhancement of PUCCH format 3 is unnecessary.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment
Apple	Fine with the proposal	

Proposal 5-3_v2

For PUCCH for Msg4 HARQ-ACK with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification cannot meet the performance requirement with at least 2.8 dB gap

RAN1 concluded that PUCCH for Msg4 HARQ-ACK should be enhanced.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment
OPPO	Yes	Agree with this proposal
OPPO2		Besides, we provide the required SNR and CNR for capturing our simulation results as follows: [11/OPPO]: (Required SNR) – (CNR) = (-3.9) – (-10.6) = 6.7 dB

Apple	Yes	We think PUCCH for Msg4 HARQ-ACK needs to be enhanced since there is no repetition on it.

Proposal 5-1_v2 (no update)

For PUCCH format 1 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Three sources observed that the existing specification can meet the performance requirement
- Three sources observed that the existing specification cannot meet the performance requirement with at least 1.6 dB gap

RAN1 concluded that enhancement of PUCCH format 1 is unnecessary.

Proposal 5-2_v2 (no update)

For PUCCH format 3 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Two sources observed that the existing specification cannot meet the performance requirement with at least 2.4 dB gap

RAN1 concluded that enhancement of PUCCH format 3 is unnecessary.

Proposal 5-3_v2 (no update)

For PUCCH for Msg4 HARQ-ACK with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification cannot meet the performance requirement with at least 2.8 dB gap

RAN1 concluded that PUCCH for Msg4 HARQ-ACK should be enhanced.

4.6. PRACH

4.6.1. Observations

Companies' inputs for LOS environment can be summarized as below:

<u>Format 0</u>

- Case 1 (GEO set 1)
  - ➢ Can the existing specification meet the performance requirement?
    - ✧ YES:

        - NO: [3/HW, HiSi] [4/Spreadtrum] [7/vivo] [11/OPPO] [13/Pana] [24/DCM] [25/Ericsson]
- Case 2 (GEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [4/Spreadtrum] [7/vivo] [11/OPPO] [13/Pana] [24/DCM] [25/Ericsson]
- Case 3 (LEO-1200 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo (w/ higher error)]
        - NO: [1/THALES] [3/HW, HiSi] [11/OPPO] [13/Pana] [24/DCM] [25/Ericsson]
- Case 4/5 (LEO-1200 set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [4/Spreadtrum] [7/vivo] [11/OPPO] [13/Pana] [24/DCM] [25/Ericsson]
- Case 6 (LEO-600 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [13/Pana]
        - NO: [25/Ericsson]
- Case 7/8 (LEO-600 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [4/Spreadtrum] [7/vivo (w/ higher error)]
        - NO: [1/THALES] [3/HW, HiSi] [11/OPPO] [13/Pana] [25/Ericsson]
- Case 9 (MEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [7/vivo] [13/Pana] [25/Ericsson]
- Case 10 (MEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [7/vivo] [13/Pana] [25/Ericsson]

<u>Format 2</u>

- Case 1 (GEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo (w/ higher error)]

        - NO: [3/HW, HiSi] [4/Spreadtrum] [6/ZTE] [11/OPPO] [13/Pana] [18/Nokia, NSB] [24/DCM] [25/Ericsson]

- Case 2 (GEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [4/Spreadtrum] [6/ZTE] [7/vivo] [11/OPPO] [13/Pana] [18/Nokia, NSB] [24/DCM] [25/Ericsson]
- Case 3 (LEO-1200 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [13/Pana] [24/DCM]
        - NO: [1/THALES] [25/Ericsson]
- Case 4/5 (LEO-1200 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo (w/ higher error)] [13/Pana (w/ higher error)]
        - NO: [1/THALES] [4/Spreadtrum] [6/ZTE] [11/OPPO] [18/Nokia, NSB] [19/QC] [24/DCM] [25/Ericsson]
- Case 6 (LEO-600 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [13/Pana]
        - NO: [25/Ericsson]
- Case 7/8 (LEO-600 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [1/THALES] [3/HW, HiSi (w/ higher error)] [4/Spreadtrum] [7/vivo] [11/OPPO] [13/Pana]
        - NO: [18/Nokia, NSB] [19/QC] [25/Ericsson]
- Case 9 (MEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo] [13/Pana]
        - NO: [25/Ericsson]
- Case 10 (MEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [7/vivo] [13/Pana] [25/Ericsson]

Format B4

- Case 1 (GEO set 1)

    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [4/Spreadtrum] [7/vivo] [11/OPPO] [13/Pana] [18/Nokia, NSB] [24/DCM] [25/Ericsson]
- Case 2 (GEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [4/Spreadtrum] [7/vivo] [11/OPPO] [13/Pana] [18/Nokia, NSB] [24/DCM] [25/Ericsson]
- Case 3 (LEO-1200 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo (w/ higher error)]
        - NO: [1/THALES] [3/HW, HiSi] [11/OPPO] [13/Pana] [24/DCM] [25/Ericsson]
- Case 4/5 (LEO-1200 set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [4/Spreadtrum] [7/vivo] [11/OPPO] [13/Pana] [18/Nokia, NSB] [24/DCM] [25/Ericsson]
- Case 6 (LEO-600 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi (w/ higher error)] [7/vivo] [11/OPPO] [13/Pana]
        - NO: [25/Ericsson]
- Case 7/8 (LEO-600 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo (w/ higher error)]
        - NO: [1/THALES] [3/HW, HiSi] [4/Spreadtrum] [11/OPPO] [13/Pana] [18/Nokia, NSB] [25/Ericsson]
- Case 9 (MEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [7/vivo] [13/Pana] [25/Ericsson]
- Case 10 (MEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [7/vivo] [13/Pana] [25/Ericsson]

FL made the following proposals based on the above summary, as in the previous sections.

4.6.1.1. 1st round

Proposal 6-1_v0

For PRACH format 0,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 1/2/4/5/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 3 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Six sources observed that the existing specification cannot meet the performance requirement
- For Case 7/8 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Five sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
Panasonic	Agree with the observation.
Spreadtrum	Support
NTT DOCOMO	Support
vivo	Fine. It should be noted in the proposal that PRACH retransmission already supported by current spec. is not considered in the evaluation for deriving these observations.
Lenovo	Support.
OPPO	We support the proposal.
Huawei, HiSilicon	Fine.
Ericsson	Agree

Proposal 6-2_v0

For PRACH format 2,

- For Case 3/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Eight sources observed that the existing specification cannot meet the performance requirement
- For Case 4/5 in LOS environment,
    - Two sources observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Eight sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal.
Panasonic	Agree with the observation.
Spreadtrum	Support
NTT DOCOMO	Support
vivo	Fine. It should be noted in the proposal that PRACH retransmission already supported by current spec. is not considered in the evaluation for deriving these observations.
Lenovo	Support.
OPPO	We support the proposal.
Huawei, HiSilicon	Yes, PRACH format 2 has the best performance than the other two formats.
Ericsson	We agree that Case 3, 6 and possibly 7 and 8 can be met but our results do not confirm that Case 9 can be met.

Proposal 6-3_v0

For PRACH format B4,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 1/2/4/5/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 3/7/8 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Six or seven sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
Panasonic	Agree with the observation.
Spreadtrum	Support
NTT DOCOMO	Support
vivo	Fine. It should be noted in the proposal that PRACH retransmission already supported by current spec. is not considered in the evaluation for deriving these observations.
Lenovo	Support.
OPPO	We support the proposal.
Huawei, HiSilicon	Yes
Ericsson	Agree

For offline discussion

Proposal 6-1_v1

For PRACH format 0,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement

- For Case 1/2/4/5/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 3 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Six sources observed that the existing specification cannot meet the performance requirement
- For Case 7/8 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Five sources observed that the existing specification cannot meet the performance requirement

Note: PRACH retransmission is not considered in evaluations.

Proposal 6-2_v1

For PRACH format 2,

- For Case 3/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Eight sources observed that the existing specification cannot meet the performance requirement
- For Case 4/5 in LOS environment,
    - Two sources observed that the existing specification can meet the performance requirement if 10% error is allowed
    - Eight sources observed that the existing specification cannot meet the performance requirement

Note: PRACH retransmission is not considered in evaluations.

Proposal 6-3_v1

For PRACH format B4,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 1/2/4/5/9/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 3/7/8 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement if 10% error is allowed

- Six or seven sources observed that the existing specification cannot meet the performance requirement

Note: PRACH retransmission is not considered in evaluations.

4.6.1.2. (Open) 2nd round

Based on the proposal 15-2, CNR is calculated as follows according to companies' inputs.

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP [dBm]	RX: G/T [dB/T]	No. of PRBs	Bandwidth [MHz]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	18.0	1.1		1.08	164.5	0.1	3.0	2.2	3.0	3.0	-18.4
									2.16							-21.4

<u>For PRACH format 0</u>

[1/THALES]: (Required SNR) – (CNR) = (-13.3) – (-18.4) = 5.1 dB

[3/HW, HiSi]: (Required SNR) – (CNR) = (-10.6) – (-18.4) = 7.8 dB

[4/Spreadtrum]: (Required SNR) – (CNR) = (-16.2) – (-18.4) = 2.2 dB

[7/vivo]: (Required SNR) – (CNR) = (-14.7) – (-18.4) = 3.7 dB

[11/OPPO]: (Required SNR) – (CNR) = (-10.1) – (-18.4) = 8.3 dB

[12/CATT]: (Required SNR) – (CNR) = (-11.2) – (-18.4) = 7.2 dB

[13/Pana]: (Required SNR) – (CNR) = (-14.7) – (-18.4) = 3.7 dB

[24/DCM]: (Required SNR) – (CNR) = (-15.1) – (-18.4) = 3.3 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-8) – (-18.4) = 10.4 dB

<u>For PRACH format 2</u>

[1/THALES]: (Required SNR) – (CNR) = (-18.5) – (-18.4) = -0.1 dB

[3/HW, HiSi]: (Required SNR) – (CNR) = (-15.6) – (-18.4) = 2.8 dB

[4/Spreadtrum]: (Required SNR) – (CNR) = (-18.5) – (-18.4) = -0.1 dB

[6/ZTE]: (Required SNR) – (CNR) = (-19.9) – (-18.4) = -1.5 dB

[7/vivo]: (Required SNR) – (CNR) = (-20.6) – (-18.4) = -2.2 dB

[11/OPPO]: (Required SNR) – (CNR) = (-16.3) – (-18.4) = 2.1 dB

[12/CATT]: (Required SNR) – (CNR) = (-16.0) – (-18.4) = 2.4 dB

[13/Pana]: (Required SNR) – (CNR) = (-19.4) – (-18.4) = -1.0 dB

[18/Nokia, NSB]: (Required SNR) – (CNR) = (-12.0) – (-18.4) = 6.4 dB

[19/QC]: (Required SNR) – (CNR) = (-13.5) – (-18.4) = 4.9 dB

[24/DCM]: (Required SNR) – (CNR) = (-17.6) – (-18.4) = 0.8 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-6.8) – (-18.4) = 11.6 dB

For PRACH format B4

[1/THALES]: (Required SNR) – (CNR) = (-14.2) – (-21.4) = 7.2 dB

[3/HW, HiSi]: (Required SNR) – (CNR) = (-12.1) – (-21.4) = 9.3 dB

[4/Spreadtrum]: (Required SNR) – (CNR) = (-14.4) – (-21.4) = 7.0 dB

[7/vivo]: (Required SNR) – (CNR) = (-17.2) – (-21.4) = 4.2 dB

[11/OPPO]: (Required SNR) – (CNR) = (-13.3) – (-21.4) = 8.1 dB

[12/CATT]: (Required SNR) – (CNR) = (-11.2) – (-21.4) = 9.2 dB

[13/Pana]: (Required SNR) – (CNR) = (-14.8) – (-21.4) = 6.6 dB

[18/Nokia, NSB]: (Required SNR) – (CNR) = (-12.0) – (-21.4) = 9.4 dB

[24/DCM]: (Required SNR) – (CNR) = (-14.1) – (-21.4) = 7.3 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-11.0) – (-21.4) = 10.4 dB

One important note as pointed out by [7/vivo] [9/MTK] is that PRACH coverage enhancement is discussed in Rel-18 Further NR coverage enhancements Work Item.

Proposal 6-4

For PRACH format 0 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Nine sources observed that the existing specification cannot meet the performance requirement with at least 2.2 dB gap

For PRACH format 2 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Seven sources observed that the existing specification cannot meet the performance requirement with at least 0.8 dB gap

For PRACH format B4 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Ten sources observed that the existing specification cannot meet the performance requirement with at least 4.2 dB gap

Whether/how specified for Rel-18 NTN coverage enhancement or not can be discussed after there is discussion progress in Rel-18 Further NR coverage enhancements Work Item.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment
OPPO	No	We should agree on the PRACH format to be enhanced and the gap, which might not need to wait for other WI progress. **Proposal 6-4-OPPO** For PRACH format 0 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB, • Nine sources observed that the existing specification cannot meet the performance requirement with at least 2.2 dB gap For PRACH format 2 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB, • Five sources observed that the existing specification can meet the performance requirement • Seven sources observed that the existing specification cannot meet the performance requirement with at least 0.8 dB gap For PRACH format B4 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB, • Ten sources observed that the existing specification cannot meet the performance requirement with at least 4.2 dB gap ~~Whether/how specified for Rel-18 NTN coverage enhancement or not can be discussed after there is discussion progress in Rel-18 Further NR coverage enhancements Work Item.~~ RAN1 concludes that at least PRACH format 2 needs to be enhanced for coverage enhancement. Note: the WI in which the PRACH coverage enhancement takes place is left for RAN plenary decision.
OPPO2		Besides, we provide the required SNR and CNR for capturing our simulation results as follows: [11/OPPO]: PRACH Format 0: (Required SNR) – (CNR) = (-10.1) – (-18.4) = 8.3 dB PRACH Format 2: (Required SNR) – (CNR) = (-16.3) – (-18.4) = 2.1 dB PRACH Format B4: (Required SNR) – (CNR) = (-13.3) – (-21.4) = 8.1 dB
ZTE		The Rel-18 CE WI is for TN, which has different enhancement target compared with NTN. In NTN, the FR1 scenario should be considered in enhancement, i.e., we may consider enhancing the PRACH format 0 or 2. However, in TN, the coverage issue is more likely to happen in FR2. Therefore, Rel-18 CE WI may not enhance PRACH as expected in NTN WI. We are not sure whether we should simply wait the Rel-18 CE WI progress.

Proposal 6-4

For PRACH format 0 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Nine sources observed that the existing specification cannot meet the performance requirement with at least 2.2 dB gap

For PRACH format 2 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Five sources observed that the existing specification can meet the performance requirement
- Seven sources observed that the existing specification cannot meet the performance requirement with at least 0.8 dB gap

For PRACH format B4 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB,

- Ten sources observed that the existing specification cannot meet the performance requirement with at least 4.2 dB gap

Alt 1: Whether/how specified for Rel-18 NTN coverage enhancement or not can be discussed after there is discussion progress in Rel-18 Further NR coverage enhancements Work Item.

Alt 2: RAN1 concludes that at least PRACH format 2 needs to be enhanced for NTN coverage enhancement.

4.7. PFD limit

On PFD limit, several companies reported simulation results. Note: 'YES' means the existing spec is sufficient; 'NO' means insufficient.

- [6/ZTE]
  - YES: PDSCH for VoIP, PDSCH for 3kbps
  - NO: SSB/Msg2/Msg4/
- [14/Xiaomi]
  - NO: PDSCH for 3kbps, PDCCH
- [21/Apple]
  - NO: PDSCH for VoIP, PDSCH for 3kbps, Msg2/Msg4/PDCCH/SSB
- [24/DCM]
  - NO: PDCCH
- [25/Ericsson]
  - YES: PDSCH for VoIP, PDSCH for 3kbps
  - NO: Msg2/Msg4/PDCCH/SSB

Besides, it seems that companies are referring different values as follows.

- [6/ZTE]
  - ?
- [14/Xiaomi] [17/ETRI] [21/Apple]:
  - ITU regulation - Table 5-2 (Rev.WRC-19); e.g., for GSO,
    - 5°-25° -128 + 0.5(δ-5) [dBW/m2/MHz]
    - 25° -90° -118 [dBW/m2/MHz]
- [24/DCM]:
  - ITU regulation - Table 21-4 (Rev.WRC-19)
    - 5°-25° −154 + 0.5(δ − 5) [dBW/m2/MHz]
    - 25°-90° −144 [dBW/m2/MHz]
- [25/Ericsson]:
  - ITU regulation - Annex to Resolution 212 (Rev.WRC-19)
    - -108.8 dBW/m2/MHz
  - When considering coexistence between terrestrial and satellite components of IMT in the 2 GHz NTN operating band (2170-2200 MHz), ITU Resolution 212 [9] can give guidance on applicable PFD levels. Resolution 212 "invites administrations […] to apply an appropriate power flux-density value to the IMT space stations in the frequency band 2 170-2 200 MHz", with reference to the Annex of the same resolution, in which bullet 2e gives an exemplary PFD value for DL (i.e., NTN satellite to TN UE) of -108.8 dBW/m2 for 1 MHz.

In addition, FL observed that companies' assumptions on distance are different; with consideration of elevation angle, or without. Firstly, assumption on PFD limitation should be aligned among companies.

4.7.1.1. 1st round

Proposal 7-1_v0

If PFD limit is considered for NTN coverage enhancement, Option 3 is assumed and elevation angle is considered for calculation of distance between satellite and UE.

- Option 1: ITU regulation - Table 5-2 (Rev.WRC-19)
- Option 2: ITU regulation - Table 21-4 (Rev.WRC-19)
- Option 3: ITU regulation - Annex to Resolution 212 (Rev.WRC-19)

Please input comment in the table below, if any.

Company	Comment
ZTE	We support option 1. For option 3, the bullet 2e is as follows:

	Consider reducing the power flux-density to a level sufficient for coexistence, for example to nominally -122 dBW/m^2 for 1 MHz^2 for the protection of some base stations or nominally -108.8 dBW/m^2 for 1 MHz for the protection of some user equipment on the Earth's surface on the territories of other administrations using this frequency band for the terrestrial IMT component. It can be observed besides -108.8 dBW/m2 for 1 MHz for UE, another PFD limit to protect BS is also provided as -122 dBW/m2 for 1 MHz in bullet 2e. It cannot be guaranteed that a satellite beam will not cover any BS. Hence, -122 dBW/m2 for 1MHz may need to be considered instead of -108.8 dBW/m2 for option 3. And -122 dBW/m2 is already lower than the formal defined values in Table 5-2 under certain elevation angles. With this consideration, we support option 1.
Xiaomi	We think that note 3 of Table 5-2 should be clarified if option 1 is adopted. Note 3- The coordination thresholds in the band 2160-2170 MHz (Region 2) and 2170-2200 MHz (all Regions) to protect other terrestrial services do not apply to International Mobile Telecommunications (IMT) systems, as the satellite and the terrestrial components are not intended to operate in the same area or on the common frequencies within these bands. (WRC-12).
vivo	Whether any additional coverage enhancement is needed for physical channels considering PFD should be further discussed. In our view, this should be deprioritized in this meeting. We can discuss this in following meetings when it's clear whether PFD should be considered for coverage enhancement or whether e.g. it should just require any service restrictions in the band overlapping area.
OPPO	We support Option 1 and share the similar view with ZTE that -122 dBW/m^2 for 1 MHz should be applied instead if option 3 is considered for PFD limitation. e) Consider reducing the power flux-density to a level sufficient for coexistence, for example to nominally −122 dBW/m^2 for 1 MHz^2 for the protection of some base stations or nominally −108.8 dBW/m^2 for 1 MHz for the protection of some user equipment on the Earth's surface on the territories of other administrations using this frequency band for the terrestrial IMT component. In addition, our simulation results with PFD limitation is not captured above in the FL summary and the DL physical channels identified with coverage issues includes PDSCH for VoIP, PDSCH for 3kbps, Msg2 PDSCH, Msg4 PDSCH and PDCCH in our evaluation.
Baicells	Maybe we can deprioritize the issue of PFD in this meeting and make evaluations based on #109-e meeting first.
Huawei, HiSilicon	Agree with vivo that before the detailed discussion on coverage enhancement on PFD limitation, we should first decide whether and how this should be considered. Based on the discussion in last meeting, it seems NTN can negotiate with the terrestrial communications to reduce/avoid the transmission power reduction.
ETRI	We support Option 1.
Ericsson	We agree that Option 3 should be assumed.

Proposal 7-2_v0

For DL channels, when PFD limitation is considered,

- For any cases in LOS environment, RAN1 observed that the existing specification of PDSCH for VoIP and PDSCH for low-data rate with 3kbps can meet the performance requirement
- For any cases in LOS environment, RAN1 observed that the existing specification of Msg2 PDSCH, Msg4 PDSCH, PDCCH, and S-SSB cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	For bullet 1, it is premature to have a conclusion. Further evaluation is needed to align the observations. For bullet 2, support.
Xiaomi	We share similar view with ZTE, no conclusion is made before aligning the evaluation assumptions and observations.
vivo	Whether any additional coverage enhancement is needed for physical channels considering PFD should be further discussed. In our view, this should be deprioritized in this meeting. We can discuss this in following meetings when it's clear whether PFD should be considered for coverage enhancement or whether e.g. it should just require any service restrictions in the band overlapping area.
OPPO	We support the 2nd bullet in the proposal, but the performance requirement cannot be met for PDSCH for VoIP and low-data rate with 3kbps when PFD limitation is considered.
MediaTek	More evaluation and understanding needed on PFD limitation and regulations in RAN1. PFD can be de-prioritized in this meeting
Baicells	FFS
Huawei, HiSilicon	We don't know how much impact on the satellite transmission power. So, we think it is premature to make this observation.
Hughes/Echo Star	Agreed with MediaTek
Ericsson	With PFD limitations it is challenging to provide a connection as the control channels' SNR targets cannot be met.

4.7.1.2. (Open) 2nd round

FL observed that which table from ITU regulation should be used is divergent and also as said previously how to use each regulation is also not aligned among companies (i.e., -108.8 [dBW/m2/MHz] or -122 [dBW/m2/MHz] or etc.). In addition, FL can see that several companies recommend deprioritizing discussions on PFD limit in this meeting. Considering this situation, it would be difficult to conclude the exact value on PFD limit.

Alternatively, based on the performance gap summarized in section 4.8 to 4.12 and the following EIRP density reported from companies, FL recommends agreeing high-level observation for PFD limitation.

EIRP density for LEO-1200

[14/Xiaomi]: 14.6 dBW/MHz

[17/ETRI]: 19.01 dBW/MHz

[21/Apple]: 20 dBW/MHz

[25/Ericsson]: 28.2 dBW/MHz

Note: EIRP density for LEO-1200 set-1 without PFD limit consideration is 40 dBW/MHz.

Proposal 7-3_v0

RAN1 observed that if PFD limit is considered, the existing specification for PDSCH/Msg2 PDSCH/Msg4 PDSCH/PDCCH/PDCCH of Msg2/SSB cannot meet the performance requirement.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

4.8. PDSCH VoIP

4.8.1. Observations

Companies' inputs for LOS environment **without PFD limit** can be summarized as below:

- Case 3 (LEO-1200 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [9/MTK] [11/OPPO] [21/Apple] [23/Baicells]
    - NO:
- Case 4 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [9/MTK] [11/OPPO] [21/Apple] [4/Spreadtrum]

- NO: [23/Baicells]

- Case 6 (LEO-600 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [9/MTK] [11/OPPO] [21/Apple] [23/Baicells]
    - NO:
- Case 7 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [9/MTK] [11/OPPO] [21/Apple] [4/Spreadtrum]
    - NO: [23/Baicells]

4.8.1.1. 1st round

Proposal 8-1_v0

On PDSCH for VoIP, when PFD limitation is not considered,

- For Case 3/4/6/7 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal.
Panasonic	Agree with the observation.
NTT DOCOMO	Support
Xiaomi	Support
vivo	Fine.
OPPO	We support the proposal.
MediaTek	Agree
Baicells	Basically OK. But we need clarification on whether beam edge loss should be considered as an evaluation assumption. In #109-e agreements, it is stated that: “For coverage performance evaluation, the following elevation angle is assumed.....these values are elevation angles at the edge of the edge beam.” We understand that at the edge of the edge beam, the link budget is 3dB less than the beam center for both DL and UL. In our evaluation, beam center and beam edge are considered respectively, which may derive different conclusion for some of these evaluation cases, eg. VoIP PDSCH case 4/7.

Huawei, HiSilicon	Support.
Ericsson	Agree

For offline discussion

Proposal 8-1_v1 (no update)

On PDSCH for VoIP, when PFD limitation is not considered,

- For Case 3/4/6/7 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement

4.8.1.2. (Open) 2nd round

Based on the proposal 15-2, CNR without PFD consideration is calculated as follows according to companies' inputs.

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP density [dBW/MHz]	RX: G/T [dB/T]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	40	-36.6	164.5	0.1	3.0	2.2	3.0	0.0	-0.8

[3/HW, HiSi]: (Required SNR) – (CNR) = (-12.8) – (-0.8) = -12 dB

[4/Spreadtrum]: (Required SNR) – (CNR) = (-7.4) – (-0.8) = -6.6 dB

[6/ZTE]: (Required SNR) – (CNR) = (-16.8) – (-0.8) = -16.0 dB

[7/vivo]: (Required SNR) – (CNR) = (-14.1) – (-0.8) = -13.3 dB

[9/MTK]: (Required SNR) – (CNR) = (-10) – (-0.8) = -9.2 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-10.3) – (-0.8) = -9.5 dB

[21/Apple]: (Required SNR) – (CNR) = (-12.9) – (-0.8) = -12.1 dB

[23/Baicells]: (Required SNR) – (CNR) = (-9.0) – (-0.8) = -8.2 dB

Proposal 8-1_v2

For PDSCH for VoIP with parameter set-1 for LEO-1200 operating at LOS without PFD limitation,

- Eight sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDSCH for VoIP is unnecessary, if PFD limit is not considered.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

4.8.2. (Closed) Whether to enhance

If Proposal 7-2_v0 is agreed, FL believes that PDSCH for VoIP can be supported regardless of PFD limit.

4.8.2.1. 1st round

Proposal 8-2_v0

For NTN coverage enhancement, RAN1 observed that enhancement of PDSCH for VoIP is unnecessary regardless of whether PFD limit is considered or not.

- VoIP is supported for Case 3/4/6/7.

Please input comment in the table below, if any.

Company	Comment
ZTE	When PFD limit is considered, further evaluation is needed to align the observations
vivo	Case 4 should be precluded according to observations from evaluation results of VoIP on PUSCH.
Samsung	agree
OPPO	We do not support the proposal. According to our evaluation, the performance requirement cannot be met when PFD limit is considered.
MediaTek	More evaluation and understanding needed on PFD limitation and regulations in RAN1. PFD can be de-prioritized in this meeting
Baicells	We share similar view with ZTE.
Hughes/Echo Star	Agreed with MediaTek
Ericsson	We do not think its relevant to enhance the NTN in NTN-TN interference scenarios outlined in Res-212.

4.9. PDSCH low-data rate service

4.9.1. Observations

Companies' inputs for LOS environment **without PFD limit** (i.e. for 1Mbps) can be summarized as below:

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [13/Pana] [14/Xiaomi] [23/Baicells] [25/Ericsson] [4/Spreadtrum]
    - NO: [12/CATT] [21/Apple]
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES: ~~[14/Xiaomi]~~
    - NO: [7/vivo] [11/OPPO] [13/Pana] [21/Apple] [23/Baicells] [25/Ericsson] [4/Spreadtrum] [14/Xiaomi]
- Case 5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [13/Pana] [14/Xiaomi] [21/Apple] [23/Baicells] [25/Ericsson] [4/Spreadtrum]
    - NO:
- Case 8 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [11/OPPO] [13/Pana] [14/Xiaomi] [23/Baicells] [25/Ericsson]
    - NO: [7/vivo] [21/Apple]
- Case 9 (MEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [13/Pana] [23/Baicells] [25/Ericsson]
    - NO:
- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [13/Pana] [23/Baicells] [25/Ericsson]

4.9.1.1. 1st round

Proposal 9-1_v0

On PDSCH for low data rate with 1Mbps, when PFD limitation is not considered,

- For Case 1/5/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 2 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - Six sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
Panasonic	Agree with the observation.
NTT DOCOMO	Support
Xiaomi	For case 2, we would like to shift our position from [Yes] to [No]. We evaluated two cases for PDSCH in our contribution, one for MCS =0 and the other is MCS = 10. And we found that when MCS=0, the requirement can be met with sacrificing large DL bandwidth, which exceeds the available bandwidth defined by RAN4. For MCS=10, the requirement can't be met, which we think is reasonable observation.
vivo	Fine.
OPPO	We support the proposal.
Baicells	Agree.
Huawei, HiSilicon	The observation seems need to be updated for case 2 considering Xiaomi's inputs above.
Ericsson	Agree

Proposal 9-1_v1

On PDSCH for low data rate with 1Mbps, when PFD limitation is not considered,

- For Case 1/5/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- ~~For Case 2 in LOS environment,~~
    - ~~One source observed that the existing specification can meet the performance requirement~~
    - ~~Six sources observed that the existing specification cannot meet the performance requirement~~

4.9.1.2. 2nd round

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP density [dBW/MHz]	RX: G/T [dB/T]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	40	-36.6	164.5	0.1	3.0	2.2	3.0	3.0	-3.8

For 3kbps

[6/ZTE]: (Required SNR) – (CNR) = (-11.8) – (-3.8) = -8.0 dB

[7/vivo]: (Required SNR) – (CNR) = (-14.5) – (-3.8) = -10.7 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-9.6) – (-3.8) = -5.8 dB

[21/Apple]: (Required SNR) – (CNR) = (-10.5) – (-3.8) = -6.7 dB

4.9.2. (Closed) Whether to enhance

4.9.2.1. 1st round

Proposal 9-2_v0

For NTN coverage enhancement, down-select from the following options

- Option 1: RAN1 observed that PDSCH should be enhanced for low-data rate with 1Mbps when PFD limitation is not considered.
    - DL low-data rate service with 1Mbps is supported for Case 1/2/5/8/9/10
- Option 2: RAN1 observed that PDSCH enhancement for low-data rate with 1Mbps is unnecessary when PFD limitation is not considered.
    - DL low-data rate service with 1Mbps is supported for Case 1/5/8/9
    - Case 2/10 are deprioritized.

Proposal 9-3_v0

For NTN coverage enhancement, down-select from the following options

- Option 1: PDSCH for low-data rate with 3kbps is deprioritized when PFD limitation is considered

- Option 2: RAN1 observed that PDSCH enhancement for low-data rate with 3kbps is unnecessary when PFD limitation is considered.
    - Option 2-1: DL low-data rate service with 3kbps is supported for Case 1/9
        - Parameter set 2 (i.e., Case 2/5/8/10) is deprioritized.
    - Option 2-2: DL low-data rate service with 3kbps is supported for Case 5/8
        - GEO/MEO (i.e., Case 1/2/9/10) are deprioritized.

Please input comment in the table below, if any.

Company	Comment
ZTE	For proposal 9-3, we do not quite understand the motivation of this proposal. The two options seem to both object the enhancement of PDSCH. We think whether to enhance 3kbps when PFD limitation is considered may be discussed after further alignment of evaluations.
Panasonic	On Proposal 9-2_v0, we prefer Option 2. Satellite parameter set 2 for GEO and MEO can be de-prioritized.
NTT DOCOMO	Proposal 9-2_v0: We prefer Option 2.
vivo	Support option 2 for both cases meaning that no PDSCH enhancement is needed without considering the PFD issue.
Samsung	For proposal 9-2_v0, we prefer option 2. For proposal 9-3_v0, it should be dependent on whether or not to agree Proposal 7-2_v0.
OPPO	For proposal 9-2, we prefer option 2 since the date rate will further decrease with the increasing number of repetitions. For proposal 9-3, the performance requirement cannot be met when PFD limit is considered, and further discussion is needed.
MediaTek	Proposal 9-2: Support Option 2 Proposal 9.3: More evaluation needed on PFD. It can be de-prioritized in this meeting
Baicells	On Proposal 9-2_v0: Option1 On Proposal 9-3_v0: Too early to determine. Whether or not to consider PFD, and what is PFD's influence should be determined firstly.
Huawei, HiSilicon	For 9-2: option 2.
Hughes/EchoStar	Proposal 9-2: Support Option 2 Proposal 9.3: More evaluation needed on PFD, should be de-prioritized in this meeting

Ericsson	We prefer to not enhance the DL. It sufficiently robust for the most vital case 6.

4.10. Msg2 PDSCH / Msg4 PDSCH

4.10.1. Observations

Companies' inputs for LOS environment **without PFD limit** can be summarized as below:

Msg2 PDSCH

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
    - NO:
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo]
    - NO: [11/OPPO] [21/Apple] [25/Ericsson]
- Case 3 (LEO-1200 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
    - NO:
- Case 4/5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
    - NO:
- Case 6 (LEO-600 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
    - NO:
- Case 7/8 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
    - NO:
- Case 9 (MEO set 1)
  - Can the existing specification meet the performance requirement?

        - YES: [7/vivo] [25/Ericsson]
        - NO:
- Case 10 (MEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo]
        - NO: [25/Ericsson]

<u>Msg4 PDSCH</u>

- Case 1 (GEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [21/Apple]
        - NO: [3/HW, HiSi] [7/vivo] [11/OPPO] [25/Ericsson]
- Case 2 (GEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES:
        - NO: [3/HW, HiSi] [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
- Case 3 (LEO-1200 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
        - NO:
- Case 4/5 (LEO-1200 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi] [21/Apple]
        - NO: [7/vivo] [11/OPPO] [25/Ericsson]
- Case 6 (LEO-600 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [21/Apple] [25/Ericsson]
        - NO:
- Case 7/8 (LEO-600 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [3/HW, HiSi] [21/Apple]
        - NO: [7/vivo] [11/OPPO] [25/Ericsson]
- Case 9 (MEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [25/Ericsson]

- NO: [7/vivo]

- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [7/vivo] [25/Ericsson]

Besides, FL found that vivo argues Msg4 can be rescheduled by NW implementation. It would be necessary to consider this aspect.

4.10.1.1. 1st round

Proposal 10-1_v0

For Msg2 PDSCH, when PFD limitation is not considered,

- For Case 1/3/4/5/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment,
  - One source observed that the existing specification can meet the performance requirement
  - Three or one sources observed that the existing specification cannot meet the performance requirement, respectively

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal
NTT DOCOMO	Support
vivo	Fine. Note that for Msg2, TB scaling is allowed since Rel-15 which should be assumed in the evaluation. No performance issue was observed in our evaluation even when 10MHz band is assumed. (Transmission band in FR1 can be up to 20MHz according to 38.101)
OPPO	We support the proposal. The coverage issues still exists even when the TB scaling factor of 0.25 is used in our evaluation.
Huawei, HiSilicon	Fine.
Ericsson	Agree

Proposal 10-2_v0

For Msg4 PDSCH, when PFD limitation is not considered,

- For Case 3/6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - Four sources observed that the existing specification cannot meet the performance requirement
- For Case 4/5/7/8 in LOS environment,
    - Two sources observed that the existing specification can meet the performance requirement
    - Three sources observed that the existing specification cannot meet the performance requirement
- For Case 9 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - One source observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal
NTT DOCOMO	Support
vivo	Fine.
OPPO	We support the proposal.
Huawei, HiSilicon	For Case 3/4/5/6/7/8 in LOS environment, we observed that the existing specification can meet the performance requirement. We found that if antenna switching/selection is used the performance can be fulfilled.
Ericsson	Agree

For offline discussion

Proposal 10-1_v1 (no update)

For Msg2 PDSCH, when PFD limitation is not considered,

- For Case 1/3/4/5/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - Three or one sources observed that the existing specification cannot meet the performance requirement, respectively

Proposal 10-2_v1 (no update)

For Msg4 PDSCH, when PFD limitation is not considered,

- For Case 3/6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2/10 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 1 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - Four sources observed that the existing specification cannot meet the performance requirement
- For Case 4/5/7/8 in LOS environment,
    - Two sources observed that the existing specification can meet the performance requirement
    - Three sources observed that the existing specification cannot meet the performance requirement
- For Case 9 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - One source observed that the existing specification cannot meet the performance requirement

4.10.1.2. (Open) 2nd round

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP density [dBW/MHz]	RX: G/T [dB/T]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	40	-36.6	164.5	0.1	3.0	2.2	3.0	3.0	-3.8

<u>For Msg2 PDSCH</u>

[6/ZTE]: (Required SNR) – (CNR) = (-9.5) – (-3.8) = -5.7 dB

[7/vivo]: (Required SNR) – (CNR) = (-15.0) – (-3.8) = -11.2 dB

Note: [7/vivo] considers 2% iBLER

[21/Apple]: (Required SNR) – (CNR) = (-11.6) – (-3.8) = -7.8 dB

For Msg4 PDSCH

[3/HW, HiSi]: (Required SNR) – (CNR) = (-7.4) – (-3.8) = -3.6 dB

[6/ZTE]: (Required SNR) – (CNR) = (-7.5) – (-3.8) = -3.7 dB

[7/vivo]: (Required SNR) – (CNR) = (-4.1) – (-3.8) = -0.3 dB

Note: [7/vivo] considers 2% iBLER

[21/Apple]: (Required SNR) – (CNR) = (-6.7) – (-3.8) = -2.9 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-5.8) – (-3.8) = -2.0 dB

Proposal 10-1_v2

For Msg2 PDSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Two sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of Msg2 PDSCH is unnecessary, if PFD limit is not considered.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

Proposal 10-2_v2

For Msg4 PDSCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Two sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of Msg4 PDSCH is unnecessary, if PFD limit is not considered.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

4.11. PDCCH

4.11.1. Observations

Companies' inputs for LOS environment **without PFD limit** can be summarized as below:

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi (CONNECTED)] [7/vivo] [11/OPPO] [12/CATT] [13/Pana] [14/Xiaomi] [21/Apple] [25/Ericsson]
    - NO: [3/HW, HiSi (IDLE)]
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES:
    - NO: [3/HW, HiSi] [7/vivo] [11/OPPO] [13/Pana] [14/Xiaomi] [21/Apple] [25/Ericsson]
- Case 3 (LEO-1200 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [12/CATT] [14/Xiaomi] [21/Apple] [25/Ericsson]
    - NO:
- Case 4/5 (LEO-1200 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [14/Xiaomi] [21/Apple]
    - NO: [13/Pana] [25/Ericsson]
- Case 6 (LEO-600 set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [12/CATT] [13/Pana] [14/Xiaomi] [21/Apple] [25/Ericsson]
    - NO:
- Case 7/8 (LEO-600 set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [11/OPPO] [14/Xiaomi] [21/Apple]
    - NO: [13/Pana] [25/Ericsson]
- Case 9 (MEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi] [7/vivo] [12/CATT] [13/Pana] [25/Ericsson]
    - NO:

- Case 10 (MEO set 2)
  - Can the existing specification meet the performance requirement?
    - YES: [3/HW, HiSi]
    - NO: [7/vivo] [13/Pana] [25/Ericsson]

4.11.1.1. 1st round

Proposal 11-1_v0

For PDCCH, when PFD limitation is not considered,

- For Case 1/3/4/5/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 10 in LOS environment,
  - One source observed that the existing specification can meet the performance requirement
  - Three sources observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal
Panasonic	Agree with the observation. Although our results for Case 4/5 (LEO1200 set2) and 7/8 (LEO600 set2) does not achieve 1% BLER, the performance gap is small. Therefore, we are ok with the observation.
NTT DOCOMO	Support
vivo	Fine. Note that up to 2 PDCCH repetitions already supported from MIMO topic are not assumed in our evaluation.
OPPO	We support the proposal.
Huawei, HiSilicon	Support. Maybe for case 10, we can add vivo's assessment above in the observations.
Ericsson	Our results do not support that performance targets are met for Case 4/5/7/8.

For offline discussion

Proposal 11-1_v1

For PDCCH, when PFD limitation is not considered,

- For Case 1/3/4/5/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 10 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement by applying two PDCCH repetitions, which was introduced in Rel-17.
    - Three sources observed that the existing specification cannot meet the performance requirement

4.11.1.2. (Open) 2nd round

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP density [dBW/MHz]	RX: G/T [dB/T]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	40	-36.6	164.5	0.1	3.0	2.2	3.0	3.0	-3.8

<u>For PDCCH</u>

[3/HW, HiSi]: (Required SNR) – (CNR) = (-10.3) – (-3.8) = -6.5 dB

[6/ZTE]: (Required SNR) – (CNR) = (-11.0) – (-3.8) = -7.2 dB

[7/vivo]: (Required SNR) – (CNR) = (-8.6) – (-3.8) = -4.8 dB

[13/Pana]: (Required SNR) – (CNR) = (-6.7) – (-3.8) = -2.9 dB

[14/Xiaomi]: (Required SNR) – (CNR) = (-8.9) – (-3.8) = -5.1 dB

[21/Apple]: (Required SNR) – (CNR) = (-10.2) – (-3.8) = -6.4 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-6.0) – (-3.8) = -3.2 dB

<u>For PDCCH of Msg2</u>

[25/Ericsson]: (Required SNR) – (CNR) = (-6.0) – (-3.8) = -3.2 dB

Proposal 11-1_v2

For PDCCH with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Seven sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH is unnecessary, if PFD limit is not considered.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

Proposal 11-2_v0

For PDCCH of Msg4 with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- One source observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH of Msg4 is unnecessary, if PFD limit is not considered.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

4.12. SSB

4.12.1. Observations

Companies' inputs for LOS environment **without PFD limit** can be summarized as below:

- Case 1 (GEO set 1)
  - Can the existing specification meet the performance requirement?
    - YES: [7/vivo] [25/Ericsson]
    - NO:
- Case 2 (GEO set 2)
  - Can the existing specification meet the performance requirement?

        - YES:
        - NO: [7/vivo] [25/Ericsson]
- Case 3 (LEO-1200 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo] [12/CATT] [25/Ericsson]
        - NO:
- Case 4/5 (LEO-1200 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo] [25/Ericsson]
        - NO:
- Case 6 (LEO-600 set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo] [12/CATT] [25/Ericsson]
        - NO:
- Case 7/8 (LEO-600 set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo] [25/Ericsson]
        - NO:
- Case 9 (MEO set 1)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo] [12/CATT] [25/Ericsson]
        - NO:
- Case 10 (MEO set 2)
    - Can the existing specification meet the performance requirement?
        - YES: [7/vivo]
        - NO: [25/Ericsson]

4.12.1.1. 1st round

Proposal 12-1_v0

For S-SSB, when PFD limitation is not considered,

- For Case 1/3/4/5/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement

- For Case 10 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - One source observed that the existing specification cannot meet the performance requirement

Please input comment in the table below, if any.

Company	Comment
ZTE	Fine with the proposal
vivo	Fine. Note that for case 10, though the performance can meet in our evaluation the margin is quite small, it's just 0.2dB.
OPPO	Fine.
Ericsson	Agree

For offline discussion

Proposal 12-1_v1 (no update)

For S-SSB, when PFD limitation is not considered,

- For Case 1/3/4/5/6/7/8/9 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 2 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement
- For Case 10 in LOS environment,
    - One source observed that the existing specification can meet the performance requirement
    - One source observed that the existing specification cannot meet the performance requirement

4.12.1.2. (Open) 2nd round

Case	Satellite orbit	Satellite parameter set	Elevation angle [degree]	Frequency [GHz]	UE antenna gain [dBi]	TX: EIRP density [dBW/MHz]	RX: G/T [dB/T]	Free space path loss [dB]	Atmospheric loss [dB]	Shadow fading margin [dB]	Scintillation Loss [dB]	Polarization loss [dB]	Additional losses [dB]	CNR [dB]
3	LEO-1200	1	30	2.0	-5	40	-36.6	164.5	0.1	3.0	2.2	3.0	3.0	-3.8

[6/ZTE]: (Required SNR) – (CNR) = (-13.6) – (-3.8) = -9.8 dB

[7/vivo]: (Required SNR) – (CNR) = (-11.2) – (-3.8) = -7.4 dB

[25/Ericsson]: (Required SNR) – (CNR) = (-9.3) – (-3.8) = -5.5 dB

Proposal 12-1_v2

For SSB with parameter set-1 for LEO-1200 operating at LOS and CNR calculated with additional loss = 3dB without PFD limitation,

- Three sources observed that the existing specification can meet the performance requirement

RAN1 concluded that enhancement of PDCCH is unnecessary, if PFD limit is not considered.

Do you agree/accept this proposal? If NO, please add comment below.

Company	NO	Comment

4.13. 1st online discussion

Proposal 1_v2 (offline consensus)

For Rel-18 coverage enhancement in NTN, NLOS environment is deprioritized.

➔ Agreed

Direction 1: firstly decide which scenario should be focused on, and then discuss observation-type scenario and/or which channel should be enhanced

Proposal

For NR-NTN coverage enhancement, parameter set-1 is prioritized.

Proposal (not discussed)

For NR-NTN coverage enhancement, LEO is prioritized.

Updated:

Proposed working assumption
For NR-NTN coverage enhancement, parameter set-1 for LEO is prioritized for VoIP
- parameter set-2 for LEO-600 can also be considered

For NR-NTN coverage enhancement, parameter set-1 for GEO/MEO is prioritized for low-data rate services

➔ No consensus

4.14. (Closed) Plan for 2nd offline/online discussion

As we discussed, deprioritizing some scenario now is quite difficult. Instead, FL suggests agreeing at least observation-type proposals for report to RAN plenary; but FL would like to ask companies whether this direction is OK. The same situation as the 1st offline session is not good. Note that NR NTN has only one (or two) remaining online session in this meeting. No agreements mean that RAN will decide this study continues during Oct/Nov. meetings.

Based on the comments from Samsung/Apple, performance gap with simulation assumptions would need to be added when observation-type proposals are tried. Meanwhile, there are a lot of inputs with different assumptions as below. FL thinks that merging these results are quite difficult. FL's current thinking is that the best value from the results with the same assumption for some feature e.g. JCE (Enabled/Disabled/window size) can be added to the proposal, but FL would like to hear companies' views.

Company	Elevation angle [degree]	Waveform (C: CP-OFDM, D: DFT-s-OFDM)	Channel model (A: NTN-TDL-A, C: NTN-TDL-C)	Evaluation scenario (R: rural, S: sub-urban)	TX antenna chains	RX antenna chains	PRBs	Modulation (2: QPSK)	Target code rate [/1024]	PUSCH mapping type	DMRS symbols	DMRS positions	Repetitions	RV	Frequency hopping (E: Enabled, D: disabled, Value: offset)	JCE window size	TBoMS	HARQ	Required SNR [dB]	Others (PC: packet combining, R-DS: residual doppler shift)
[1/THALES]		D	C		1	1	4	2	193	A	3	2,7,11	1	0	D	D			-2.3	
													2	02		2			-5.3	
													4	0231		2			-8.0	
													8	0231..		2			-10.8	
													16	0231..		2			-13.4	
													20			2			-14.2	
[3/HW, HiSi]	30	D	C	R	1		2	2	379	A	2	2,11	4		D		4		-5.51	
													5				4		-6.27	
													5				4		-7.98	Antenna switching
[4/Spreadtrum]	30	D	D(?)		1		2				2		20						-10.34	
[5/NTPU]	30						1	2					20						-8.61	
							2	2					32						-11.25	PC
[6/ZTE]	30		C		1	1	2	2					20					D	-7.55	
[7/vivo]	30	D	C		1	2	2	2		A	2	3,11	20		D	D			-10.35	(merged)
																20			-12.26	(merged)
															E	D			-10.39	(merged)
[9/MTK]	30	C	C		1	1	5	2	120				20						-10	
[12/CATT]	30	D	C		1		6	2	110		2	3,10	16		D			D	-12	
[13/Pana]	30	D	C		1	2	1	2			2		20		E	10		D	-8.4	
[14/Xiaomi]	30						3	2					20						-13.5	
[18/Nokia, NSB]	30		C				4	2	193				20					D	-5	
[19/QC]	30		C				1				2		1			D			10.7	R-DS
													4			D			1.2	R-DS
													4			E			0.6	R-DS
													16			D			-3.7	R-DS
													16			E			-6.0	R-DS
													2			D			7.6	R-DS, PC
													8			D			0.1	R-DS, PC
													8			E			-1.3	R-DS, PC
													32			D			-4.6	R-DS, PC
													32			E			-7.6	R-DS, PC
[21/Apple]	50	D	C		1		3	2	251		2		20	0231..	D				-9.3	
							6	2	120										-11.7	
[23/Baicells]	30		C	R			2						20						-8.3	
[24/DCM]	30	D	C	R	1	2	2	2			3	pos3	20		E	D	D	D	-6.0	
[25/Ericsson]	30	D	C	R	1	1	2	2					16			E		D	-5.3	
													20			E			-6.3	

Q1: Which direction should be tried at the next online session (probably on Thursday)

- Option 1: Continue discussion of deprioritizing scenario and/or deciding a specific simulation assumption
  - ➢ FL observation: RAN plenary will decide to continue this study till Dec. plenary since there is no information on which channel in the existing spec is insufficient and/or on performance gap.
- Option 2: Discuss observation-type proposals with gap information
  - ➢ FL observation: It might be possible that RAN plenary can decide which scenario is deprioritized and which channel should be enhanced, might not.
- Option 3: Others

Company	Option	Comment

vivo	Option 3	From our perspective, it should be enough to capture observations into FL summary, no agreement is needed for observations. In this meeting, RAN1 should discuss and decide which cases should be prioritized for the two services, i.e. VoIP and low data rate. In addition, RAN1 should also discuss and decide which channels should be enhanced. The detailed coverage enhancement techniques can be further discussed in the following RAN1 meetings. In the next RAN plenary (RAN#97), companies can discuss and decide the detailed objectives for coverage enhancement in NTN according to outcome from this RAN1 meeting.
NTT DOCOMO	Option 2	We don't think it is beneficial to spend time aligning simulation assumptions and results. The simulation results already obtained should be used as a basis for discussion of observation-type proposals.
Baicells	Option3	We propose to choose the mid-value or the 25 percentile value (among all companies' data of performance gap) for each case (case 1 to case10). Deprioritize cases with huge gaps (apparently unpractical cases). Take the rest cases and its physical channels as the goal for NTN coverage enhancement.
Ericsson	Option3	Its only Tuesday and we should continue the discussions to reach a WF that is acceptable to all. The WF should preferably identify scenarios of relevance and channels to enhance.
LG	Option 3	We think that RAN1 can discuss further which channels should be enhanced after prioritizing for scenarios and/or simulation sets.

(Draft for Alt 2 below) proposal 2-1

On PUSCH for VoIP,

- For Case 6 in LOS environment, RAN1 observed that the existing specification can meet the performance requirement
- For Case 4 in LOS environment, RAN1 observed that the existing specification cannot meet the performance requirement with the following gap
    - (R1-xxxx, vivo) xx dB gap when the following assumptions are used: 1T2R, 2 PRBs, QPSK, 2 DMRS symbols, 20 repetitions with DMRS bundling of window size = 20.
    - (R1-xxxx, THALES) xx dB gap when the following assumptions are used: 1T1R, 4 PRBs, QPSK, 3 DMRS symbols, 20 repetitions with DMRS bundling of window size = 2.
    - …
- For Case 3 in LOS environment,
    - Seven sources observed that the existing specification can meet the performance requirement
    - Six sources observed that the existing specification cannot meet the performance requirement
- For Case 7 in LOS environment,

- Five sources observed that the existing specification can meet the performance requirement
- Nine sources observed that the existing specification cannot meet the performance requirement

Q2: If Option 2 of above is selected, how should performance gap be determined

- Alt 1: List all simulation results
  - ➢ FL observation: This option would not help to conclude this study at RAN plenary.
- Alt 2: Pick up the best value from the results with the same assumption for some feature e.g. JCE, as above draft proposal.
  - ➢ FL observation: one or a few results can be reported to RAN plenary, and further discussion at RAN plenary can be expected
- Alt 3: Others

Company	Alt	Comment
NTT DOCOMO	Alt 2	We don't think it's a good idea to present too much information.
Baicells	Alt3	Pick up the median (or 25% percentile value) instead of the best value for each channel and case.

4.15. (Open) High-level observations and target

Based on inputs above and offline discussion with several companies, it seems that prioritizing some scenarios and also having conclusion in this meeting can/should be tried.

In addition, FL talked yesterday's proposed working assumption with QC/Ericsson. At the last online session, the proposal was made based on Ericsson's comment, but QC argued that set-2 should also be considered. Then now QC is **OK with set-1 only, if additional 3dB loss is considered for low data rate service**. Only considering set-1 for LEO-600/1200 means that we can consider only the best case for each of LEO-600/1200 but considering robustness for actual commercial service is good/necessary approach, which is the intention to consider the additional loss. This is FL's understanding, and this should be OK for other companies since even in this case, companies' preferring channel for enhancement is still to be enhanced. Hopefully this compromised proposal can be accepted.

For this direction, FL suggests the following steps with proposals.

1st step: high-level observation-type proposal is tried

Proposal 15-1
For NR-NTN coverage enhancement, RAN1 observed for GEO and MEO that the existing specification cannot meet the performance requirement for evaluated channels/signals with significant performance gap.

2nd step: based on the above, which value/scenario/set is the target is determined

Proposal 15-2

For NR-NTN coverage enhancement, link budget of parameter set-1 for LEO-1200 operating at LOS is considered as the target to evaluate whether each channel/signal with the existing specification satisfies the performance requirement or not. The targeted performances are:

- VoIP using AMR 4.75 kbps
- Low data rate of 3 kbps. This target should be met for an additional link budget margin of 3 dB, i.e., CNR is calculated with additional loss = 3dB.

3rd step: based on the above, conclude for the target whether each channel/signal with the existing specification satisfies the performance requirement or not, with performance gap

To be added:

UL channels/signals

DL channels/signals without PFD consideration

DL channels/signals with PFD consideration

Proposal 15-1

For NR-NTN coverage enhancement, RAN1 concluded that GEO and MEO are de-prioritized ~~for which it has been observed that the existing specification cannot meet the performance requirement for evaluated channels/signals with significant gap between CNR and required SNR~~.

Q1: Do you agree/accept this high-level observation? If NO, please add comment below.

Company	YES/NO	Comment
Samsung		Although we understand the motivation, wording should be very clear to who don't follow this discussion. In that sense, we prefer to use approximate value (e.g., avg., min., max. among companies results) instead of using "significant". Also, "performance gap" seems ambiguous to us. It may be better to change as "SNR difference between link budget results and LLS results." in order to provide more accurate information.
FL		To Samsung, Thank you for quick response. Regarding using approximate value, FL thinks that it should be avoided. Based on companies' inputs so far, consuming time for determining which value should be stated would not be preferred. The intention of this proposal is to make the next proposal, so 'significant' would

		be OK. Someone does not follow this discussion can find this summary and/or companies' contributions. On 'performance gap', exactly more concrete terminology may be better. Let me think it.
vivo		In our understanding, the intention of first step is to de-prioritize GEO/MEO cases according to the observations, if an agreement is expected, this proposal should be updated as following: **Proposal 15-1** For NR-NTN coverage enhancement, RAN1 should de-prioritize ~~observed for~~ GEO and MEO for which it has been observed that the existing specification cannot meet the performance requirement for evaluated channels/signals with significant performance gap.
LG	YES	We agree the intention of the proposal and can support the proposal and vivo's modification.
Lenovo		Agree.
Baicells	YES	It can simplify further discussions.
Panasonic	NO	Fine to de-prioritize GEO/MEO to determine the channel/signals to be enhanced. But, because significant performance gap might not be true for GEO/MEO parameter set 1 and LOS according to observation in section 4.2-4.12, we would prefer the following simple description. For NR-NTN coverage enhancement, RAN1 concluded that GEO and MEO are de-prioritized for the determination of channels/signals to be enhanced.
ZTE	No	GEO is an important component of NTN and the low data rate service should be at least supported for GEO.
FL		To Panasonic There is a request to include observation on why GEO/MEO are deprioritized. But if observation on MEO part is controversial, then let's remove that part. I think no need to spend time for details on MEO. To ZTE Most companies reported that there is significant gap for GEO and it is difficult/impossible to support 3kbps in GEO. In addition, this WI does not have large TU. If GEO is considered, definitely time is insufficient. Hopefully you understand this situation.
Huawei, HiSilicon	Yes	Let's just conclude that GEO/MEO scenarios are deprioritized. We are fine with the current proposal.
LG	Yes	Fine with the proposal.

OPPO	No	The proposal as it is does not provide sufficient information to RAN plenary and we should justify why RAN1 decides to deprioritize GEO/MEO so that the RANP guys could understand.
FL		Based on comment so far, FL suggests keeping the current proposal. To OPPO, Yes, if some observation text can easily be agreed, the direction would be better. However, at least one company does not believe that MEO has significant gap. How can we solve this case? Even if the observation text is removed, anyway our conclusion is not changed; GEO/MEO are deprioritized. Nothing is changed, so the current proposal should be OK.

Proposal 15-2

For NR-NTN coverage enhancement, link budget of parameter set-1 for LEO-1200 operating at LOS is considered as the target to evaluate whether each channel/signal with the existing specification ~~satisfies the performance requirement~~ needs to be enhanced or not. The targeted performances are used to evaluate the following services:

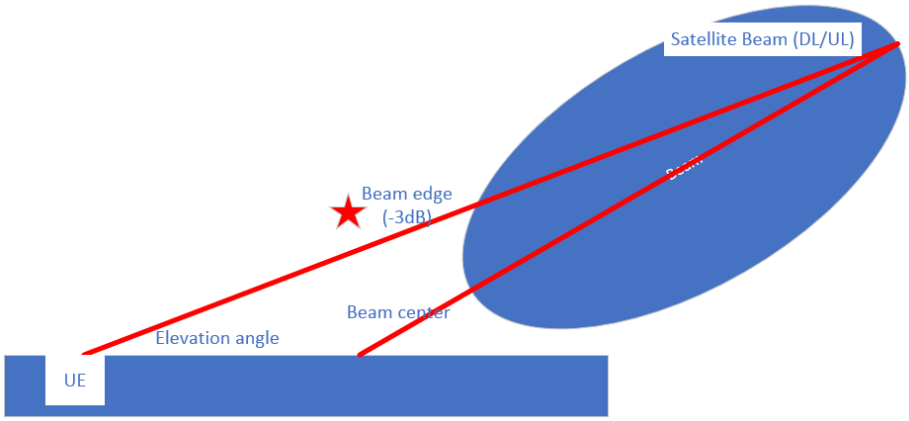
- VoIP using AMR 4.75 kbps. [This target should be met for an additional link budget margin of 3 dB, i.e., CNR is calculated with additional loss = 3dB.]
- Low data rate of 3 kbps. This target should be met for an additional link budget margin of 3 dB, i.e., CNR is calculated with additional loss = 3dB.
    - Note: this means that channels/signals other than PDSCH/PUSCH for data are evaluated with the additional loss = 3dB.

Q2: Do you agree/accept this target determination with compromise? If NO, please add comment below.

Company	YES/NO	Comment
Samsung		Why do we consider LEO-1200 instead of LEO-600? This is because FL explained "Only considering set-1 means that we can consider only the best case but considering robustness for actual commercial service is good/necessary approach,". I think that LEO-600 is the best case among LEO scenarios in terms of CNR. Perhaps, we miss some logic between them.
FL		To Samsung, My explanation should have been "Only considering set-1 for LEO-600/1200 means that we can consider only the best case for each of LEO-600/1200 but considering robustness for actual commercial service is good/necessary approach,". Anyway, this proposal means that we focus on LEO. And since definitely LEO-1200 is worse than LEO-600, LEO-1200 becomes the target. The target is the best for LEO-1200, and hence some performance margin is considered additionally.

vivo		Regarding the additional 3dB margin in low data rate service, is it intended only for PUSCH, or is it also applicable for other channels required to support low data rate service? For example, PRACH.
FL		To vivo, All channels/signals including PRACH. The main bullet is saying 'each channel/signal'. This would be sufficient for the clarification.
LG		First of all, the agreement should be for bottleneck identification rather than general evaluation for NTN. We already have agreed assumption of coverage evaluation and evaluated. As companies mentioned, remaining work would be define target channel for enhancement. We think the proposal should be revised as following: **Proposal 15-2** For NR-NTN coverage enhancement, link budget of parameter set-1 for LEO-1200 operating at LOS is considered as the target to evaluate whether each channel/signal need to be enhanced or not. The targeted performances are: As provided by companies' evaluations, VoIP and low data service is a target service only for PDSCH and PUSCH evaluation. All other channel has agreed channel parameters and target so it is difficult to say that VoIP and low data is a "targeted performance" for evaluation. If current framework need to be maintained, we would like to add "Initial access procedure" at least for msg2/3/4 PDSCH/PUCCH/PUSCH.
Lenovo		We share similar view as Samsung that LEO 600 should also be considered which may achieve the best performance. Anyway, if LEO-1200 is the majority view, we are also fine.
Xiaomi		We have similar question with vivo. Regarding the additional 3dB margin, we think the requirements of non-data channels such as PRACH and PUCCH for different services should be the same. Does Proposal 15-2 mean that we have two CNR for LEO-1200 Set1, one with additional 3dB for comparing SNR of each channel, the other without additional 3dB comparing SNR of each channel? We suggest change **Proposal 15-2** as following: For NR-NTN coverage enhancement, link budget of parameter set-1 for LEO-1200 operating at LOS with an additional link budget margin of 3 dB, i.e., CNR is calculated with additional loss = 3dB is considered as the target to evaluate whether each channel/signal with the existing specification satisfies the performance requirement or not. The targeted ~~performances~~ service are: • VoIP using AMR 4.75 kbps Low data rate of 3 kbps. ~~This target should be met for an additional link budget margin of 3 dB, i.e., CNR is calculated with additional loss = 3dB.~~
Baicells		We have similar view with Xiaomi. If the additional link budget margin of 3dB is required, it should be required for all cases.

		Also, we have mentioned in the 1st round discussion: In #109-e agreements, it is stated that: "For coverage performance evaluation, the following elevation angle is assumed.....these values are elevation angles at the edge of the edge beam." We understand that at the edge of the edge beam, the link budget is 3dB less than the beam center for both DL and UL.
Panasonic		We have similar question with vivo and Xiaomi. Clarification on why 3dB additional loss is added only for low data rate case (not for VoIP) is needed.
ZTE		We think set-2 should also be considered. And w.r.t the 3dB margin, clarification is needed on which channel will be considered. Is the additional 3dB loss only for PUSCH or also for other channels such as PRACH, etc. Moreover, GEO is an important component of NTN and the low data rate service should be at least supported for GEO set-1. In order to ensure GEO can be supported, its link budget (which is lower than LEO-1200 set-1 with 3dB additional loss) should be the target for low data rate.
FL		Based on comments so far, it would be better to clarify that the 3 dB additional loss is also considered for other channels/signals. That is, only for PUSCH/PDSCH for VoIP, 3dB loss is not considered. In FL's understanding, why 3dB loss is not considered for VoIP is, that VoIP needs higher data rate and thus it is a bit difficult to consider the 3dB loss for VoIP. This compromised way is OK from perspective of QC who has concern on deprioritizing set-2. Hopefully companies are OK with this proposal. Anyway, as FL said above, 3dB loss is considered for all channels except for PUSCH for VoIP. To Baicells, Although FL understands the aspect, there is no such an argument from other companies. And simulation assumption was already agreed at the last meeting, so current proposal should be OK. To ZTE, Please see my reply in Q1 above.
Huawei, HiSilicon		We agree that LEO-1200 set1 can be taken as the target scenarios for our coverage evaluations. We think the point is LEO-600 set1 has better CNR values in link budget analysis and LEO-600 set2 has similar CNR values as that of LEO-1200 set1. So, use LEO-1200 set1 would be sufficient. However, we cannot agree to add another 3dB loss. Firstly, we have already agreed the link budget analysis assumption and why should we revert the related agreement. This additional 3dB loss for 3kbps data rate seems technically incorrect. We are fine with other part in general.
LG		We are supportive with the intention of the proposal. But it is hard to be convinced with additional 3dB loss on specific channel without technical explanation.

		For our understanding, handheld type of UE is considered for both services so there wouldn't be difference at least on UE side. We understand that it is not desirable to pick up best evaluation scenarios (and LEO-1200 is not the best case), it is also not desirable to have artificial assumption on specific channel to make worse scenarios. In our view, if additional loss needs to be considered for some reasons, it should be applied all of the channel without an exception. Otherwise, it should be an optional assumption up to companies' preference.
OPPO		We don't understand why the additional 3dB loss is added. To us, we should use the agreed link budget to evaluate the performance.
Baicells		To FL and all, Our concern is not on simulation assumption, but on link budget calculation. And the concern is precisely based on the agreements in #109-e meeting. **Agreement** For coverage performance evaluation, the following elevation angle is assumed. • 30 deg for LEO, 12.5 deg for GEO-Set 1, 20 deg for GEO-Set 2, as in in Table 6.1.3.2-1 of TR38.821 ○ Note: For GEO-Set 1, channel parameters for 10 deg is used in LLS. • 30 deg for MEO • Other elevation angles can be evaluated as optional • Note: these values are elevation angles at the edge of the edge beam. If we look at the agreement above, and think about the scenario that UE is at the edge of beam, the EIRP for DL and G/T for UL will be 3dB less than their nominal value. This should be taken into account when we calculate the CNR. Actually, if we ignore the concern, then UE may not be able to have proper performance in the coverage other than at the beam center. 

vivo		Thanks for FL's clarification. As commented by majority companies, we do not think such 3dB margin is needed either.
FL		Thanks for inputs so far. Considering companies' views, and argument from Baicells, it might be possible that 3dB loss is considered for all including PUSCH with VoIP. I added the same loss for VoIP, but with brackets. Let's discuss it in the next offline discussion.

5. Contribution summary

5.1. PUSCH for VoIP

[1/THALES]

Observation 3. For VoNR AMR 4.75 kbps with 720 kHz bandwidth, in LEO-1200 with SAT Set2 parameters in S band, the achievable UL SNR is -19.62 dB, whereas the required SNR is -14.2 dB with 20 PUSCH repetitions. A repetition level greater than 20 PUSCH repetitions will be needed (FFS: 32). Of course, this will have an impact on the latency. Other potential techniques needto be investigated.

Observation 7. For VoNR AMR 4.75 kbps with 720 kHz bandwidth, in LEO-1200 with SAT Set1 parameters in S band, the achievable UL SNR is -13,62 dB, whereas the required SNR is -14.2 dB with 20 PUSCH repetitions. A repetition level of 20 PUSCH repetitions should be considered to support VoNR in LEO-1200 with SAT Set1 parameters.

Observation 12. For VoNR AMR 4.75 kbps with 720 kHz bandwidth, in LEO-600 with SAT Set2 parameters in S band, the achievable UL SNR is -14.23dB, whereas the required SNR is -14.2 dB with 20 PUSCH repetitions. More than 20 PUSCH repetitions should be considered.

[3/HW, HiSi]

Observation 13: To support VoIP service, LEO-600 satellite with Set-1 setting can provide the coverage for PDCCH, PDSCH, PRACH and PUSCH for Msg3, but not for PUSCH and PUCCH.

- For LEO-600 with Set-1, PUSCH would need to be enhanced by 3.4 dB, PUCCH format 1 of Msg4 would need to be enhanced by 10dB, and PUCCH format 3 would need to be enhanced by 2.8 dB for VoIP.

- With those enhancements, the coverage for VoIP would also be achieved for all channels for LEO-1200 in NTN-TDL-C with Set-1, and for LEO-600 in NTN-TDL-C with Set-2.

[4/Spreadtrum]

Observation 5: For VoIP, in LEO-1200, (i.e., Case 4), there is a large gap between the SNR value required to achieve 2% BLER of PUSCH transmission and the calculated CNR.

Observation 7: For VoIP, in LEO-600, (i.e., Case 7), the gap between the SNR value required to achieve 2% BLER of PUSCH transmission and the calculated CNR is 2.69dB.

[5/NTPU]

Observation 1: Both LEO-600 and LEO-1200 with satellite parameter set 1 can reach target SNRs.

Observation 2: Due to low CNR, LEO-1200 with satellite parameter set 2 cannot reach target SNRs with and without packet combining.

Observation 3: The coverage performance of rep.20 without packet combining is slightly better than that of rep.32 with packet combining.

[6/ZTE]

Observation 3: Coverage enhancement should be considered for VoIP on PUSCH due to large coverage gap.

- Up to 6.07 dB gap for LEO-1200 with Set-2.

[7/vivo]

Observation 7:

- Frequency hopping provides little gain in both NTN-TDL-A and NTN-TDL-C cases.
- JCE provides around 2dB gain in both LOS and NLOS conditions.
- PUSCH VoIP can work with all LEO scenarios except LEO-1200 set-2 satellites in LOS condition when JCE is enabled.
- 4.36dB performance gap is required to support PUSCH VoIP for LEO-1200 set-2 satellites, which can hardly be achieved due to 20ms TTI requirement for a voice packet.

Proposal 7:

- Support JCE of PUSCH in NTN and prioritize LEO scenarios except LEO-1200 set 2 scenarios.

[9/MTK]

Observation 4: VoIP cases 3,6,7 can be supported with UL repetition level up to 20.

[11/OPPO]

Observation 5: VoIP service can be supported in all LEO scenarios for DL and can only be supported in LEO600 set1 for UL.

Observation 6: VoIP service can be supported for UL in a specific elevation angle range, e.g., the elevation angle larger than 50 degree in LEO600 set2 and LEO1200 set1.

[12/CATT]

Observation 3: PUSCH for VoIP can achieve a BLER 10-2 and meet requirements of link budgets by existing Rel-17 CE technologies based on NTN-TDL-C in LEO-600 set-1.

[14/Xiaomi]

- LEO-1200 set2 have coverage issue for VoIP service in UL, DL is okay if PFD not considered

Proposal 1: PUSCH coverage enhancement for 3kbps service and VoIP service should be studied.

[15/Samsung]

Observation 4: PUSCH VoIP can meet coverage requirement for LEO-600 set-1. For LEO-600 set-2 and LEO-1200 set-1 the coverage requirement is marginally met. For LEO-1200 set-2 the coverage requirement is not met.

Observation 5: PUSCH VoIP may meet coverage requirement for LEO-600 set-2 and LEO-1200 set-1 when at least one of frequency hopping and TBoMS is considered.

Proposal 3: It is recommended that PUSCH VoIP is supported for LEO-600 (set-1/2) and LEO-1200 (set-1).

[18/Nokia, NSB]

Observation 7. From the analysis performed in this section, it can be observed that the Rel17 UL coverage enhancement methods and techniques cannot close the target link budget SNRs for NR NTN. Thus, solutions beyond Rel17 UL coverage enhancements are needed.

[19/QC]

Observation 1: For the AMR 4.75kbps voice codec and a satellite with the Set-2 parameters, with TBoMS, DMRS bundling, antenna switching and 32 repetitions for PUSCH, and voice frame aggregation, a commercial smart phone and a satellite with the Set-2 parameters can support elevation angle of 40 degrees or higher for 600kM satellite altitude.

[21/Apple]

Observation 1: At 2% BLER, the required SNR for PUSCH with VoIP is -11.7 dB or -9.3 dB with 6 PRBs or 3 PRBs for 20 repetitions, respectively.

[23/Baicells]

Observation 10: For uplink, VoIP, 20 repetitions, without packet combining, 2PRB, rural LOS scenario, 2%BLER, the required SNR is -8.3 dB. The link budget margin is in the range of [-11.3, 0.1]dB.

Proposal 2: For NTN uplink, coverage enhancements are necessary for both VoIP and low data rate service.

[24/DCM]

Observation 1: PUSCH coverage enhancement is needed for both GEO and LEO-1200.

Proposal 1: Specify some mechanism for PUSCH coverage enhancements.

[25/Ericsson]

Observation 1 With handheld devices with realistic assumptions on antenna gain, VoIP coverage is a challenge with the evaluated configuration (up to 20 PUSCH repetitions and cross-slot channel estimation) except in the LEO600 scenario with satellite parameter set 1.

5.2. PUSCH for low-data rate service

[3/HW, HiSi]

Observation 15: PUSCH is also the bottleneck for a low data rate of 100kbps with larger coverage gaps, compared to VoIP.

[4/Spreadtrum]

Observation 4: For Low-data rate service, in GEO (i.e., Case 1 and Case 2), there is a large gap between the SNR value required to achieve 10% BLER of PUSCH transmission and the calculated CNR.

Observation 6: For Low-data rate service, in LEO-1200 (i.e., Case 5), there is a large gap between the SNR value required to achieve 10% BLER of PUSCH transmission and the calculated CNR.

[5/NTPU]

Proposal 1: For uplink low-date rate service, 3 kbps data rate applies for MEO/GEO, 100 kbps data rate applies for LEO.

[6/ZTE]

Observation 4: Coverage enhancement should be considered for low data rate service on PUSCH.

- Up to 2.62 dB gap for LEO-1200 with Set-2
- Up to 4.9 dB gap for GEO with Set-1
- Up to 9.68 dB gap for GEO with Set-2

[7/vivo]

Observation 8:

- 32 repetitions with JCE are enough to support PUSCH 3kbps data rate with set-1 satellites in LOS condition.
- 4.68dB and 5.4dB coverage enhancement are required to support PUSCH 3kbps data rate in LOS condition for GEO set-2 and MEO set-2 satellites respectively.
- Increasing repetition number would not help that much to improve the performance of PUSCH with 3kbps data.

Proposal 8:

- For PUSCH 3kbps data rate, only focus on set-1 satellites for MEO/GEO cases.
- For PUSCH 3kbps data rate, increasing repetition number beyond 32 should be de-prioritized.

Observation 9:

- Up to 13dB, 18.36dB and 19.25dB coverage enhancements are required to support PUSCH 100kbps data rate in LEO, GEO and MEO scenarios respectively.

Proposal 9:

- RAN1 should deprioritize 100kbps on PUSCH for Rel-18 NTN coverage enhancement study.

[11/OPPO]

Observation 1: 3kbps UL data rate cannot be supported in GEO set1, GEO set2 and LEO1200 set2, but it can be supported in LEO600 set1, LEO1200 set1 and LEO600 set2.

Observation 2: 100kbps UL data rate cannot be supported in all satellite scenarios.

Observation 3: The achievable UL data rate in different satellite scenarios is as follows:

- GEO set1: 1kbps
- GEO set2: low data rate service cannot be supported
- LEO600 set1: 40kbps
- LEO1200 set1: 10kbps
- LEO600 set2: 10kbps
- LEO1200 set2: 1kbps

[12/CATT]

Observation 4: PUSCH for low data rate can achieve a BLER 10-1 and meet requirements of link budgets by existing Rel-17 CE technologies based on NTN-TDL-C in LEO-600 set-1/2 and LEO-1200 set-1.

[14/Xiaomi]

- All scenarios except LEO-600 set2 have coverage issue for 3kbps service in UL

- All scenarios have coverage issue for 100kbps service in UL, DL with low MCS is okay if PFD not considered.

Proposal 1: PUSCH coverage enhancement for 3kbps service and VoIP service should be studied.

[18/Nokia, NSB]

Observation 7. From the analysis performed in this section, it can be observed that the Rel17 UL coverage enhancement methods and techniques cannot close the target link budget SNRs for NR NTN. Thus, solutions beyond Rel17 UL coverage enhancements are needed.

[21/Apple]

Observation 2: At 10% BLER, the required SNR for PUSCH with 3 kbps is -7.5 dB with 1 PRB for 8 repetitions and is -14.5 dB with 4 PRBs for 32 repetitions.

Observation 3: At 10% BLER, the required SNR for PUSCH with 100 kbps is -3.2 dB with 4 PRBs without repetition.

[23/Baicells]

Observation 11: For uplink, low data rate service, 3kbps, 32 repetitions, coding rate = 0.15, rural LOS scenario, 10%BLER, our simulation result is that the required SNR is -12.3dB. The link budget margin is in the range of [-14.5, 1.9]dB. For example, for case 2 (GEO, set2), link budget margin is -14.5dB.

Observation 12: For uplink, low data rate service, 100kbps, 32 repetitions, coding rate = 0.32, rural LOS scenario, 10%BLER, our simulation result is that the required SNR is -13.0dB. The link budget CNR is far below the required SNR.

Proposal 2: For NTN uplink, coverage enhancements are necessary for both VoIP and low data rate service.

[24/DCM]

Observation 1: PUSCH coverage enhancement is needed for both GEO and LEO-1200.

Proposal 1: Specify some mechanism for PUSCH coverage enhancements.

5.3. Msg3 PUSCH

[1/THALES]

Observation 4. For LEO-1200 with SAT Set2 parameters in S band, PUSCH msg3 is also one of the coverage bottlenecks as the achievable UL SNR is -16.61 dB, whereas the required SNR is equal to -14.6 dB with 20 repetitions. Hence, PUSCH msg3 coverage shall be also enhanced.

Observation 8. For LEO-1200 with SAT Set1 parameters in S band, PUSCH msg3 the achievable UL SNR is -10,61dB. The required SNR with 8 PUSCH repetitions being equal to -11.6 dB, PUSCH repetition level equal to 8 is needed.

Observation 13. For LEO-600 with SAT Set2 parameters in S band, PUSCH msg3 the achievable UL SNR is -11.22dB. The required SNR with 16 PUSCH repetitions being equal to -14 dB, PUSCH repetition level equal to 16 is needed.

[6/ZTE]

Observation 2: Enhancement should be considered for legacy Msg3 (with 16 repetition) due to large coverage gap.

- 1.82 dB gap for LEO-1200 with Set-2.

- Up to 4.1 dB gap for all GEO scenarios with Set-1.
- Up to 8.88 dB gap for all GEO scenarios with Set-2.

[7/vivo]

Observation 10:

- Without target data rate requirement, increasing repetition number could provide significant performance gain for Msg3.
- In LOS condition, 48 repetitions are enough to support PUSCH Msg3 for LEO/MEO/GEO set-1 satellites and LEO set-2 satellites.
- With 64 repetitions, 5.67dB and 4.68dB performance gap is observed for MEO set-2 and GEO set-2 satellites respectively, which can be compensated via more retransmissions on top of the up to 16 repetitions supported already for Msg3.

Proposal 10:

- No enhancement of PUSCH Msg3 is needed for Rel-18 NTN.

[11/OPPO]

Observation 7: The following physical channels in the initial access have coverage issues in GEO scenario: PRACH, PDCCH, Msg2 PDSCH, Msg3 PUSCH, Msg4 PDSCH and Msg4 PUCCH

Observation 8: The following physical channels in the initial access have coverage issues in LEO scenario due to lack of coverage enhancement techniques: PRACH, Msg4 PDSCH and Msg4 PUCCH.

[12/CATT]

Observation 5: PUSCH MSG3 can achieve a BLER 10-1 and meet requirements of link budgets by existing R17 CE technologies based on NTN-TDL-C in LEO-600 set-1/2 and LEO-1200 set-1.

[13/Pana]

Proposal 2: Improvement for the following channels should be considered, PUSCH msg3, PUCCH format 3, PRACH format 2 and PDCCH.

[14/Xiaomi]

- GEO scenarios and LEO-1200 set2 have coverage issue for Msg 3

Proposal 3: Msg.3 coverage enhancement should be studied in NTN.

[19/QC]

Observation 4: Msg3 is a bottleneck channel for supporting low-data rate services over commercial smart phones in NTN.

[21/Apple]

Observation 4: At 10% BLER, the required SNR for PUSCH Msg 3 is -11.8 dB, -9.7 dB, -7.5 dB, -5 dB and -2.5 dB at repetition of 16, 8, 4, 2 and 1, respectively.

5.4. PUCCH / Msg4 PUCCH

[7/vivo]

Observation 12:

- Maximum performance gap is observed in MEO Set-2 scenario for both PUCCH formats.

- For dedicated PUCCH, up to 8.13 dB and 13.52dB enhancements are required in LOS condition for PUCCH format 1 and format 3 respectively.
- For Msg4 PUCCH, it has worst performance in PUCCH format 1 study, and requires up to 12.67dB enhancements in LOS condition.

Proposal 12:

- Support PUCCH repetition for Msg4 ACK feedback.

[11/OPPO]

Observation 7: The following physical channels in the initial access have coverage issues in GEO scenario: PRACH, PDCCH, Msg2 PDSCH, Msg3 PUSCH, Msg4 PDSCH and Msg4 PUCCH

Observation 8: The following physical channels in the initial access have coverage issues in LEO scenario due to lack of coverage enhancement techniques: PRACH, Msg4 PDSCH and Msg4 PUCCH.

[12/CATT]

Observation 6: PUCCH format3 can achieve a BLER 10-2 and meet requirements of link budgets by exsiting R17 CE technologies based on NTN-TDL-C in LEO-600 set-1/2 and LEO-1200 set-1 and MEO set-1.

[13/Pana]

Proposal 2: Improvement for the following channels should be considered, PUSCH msg3, PUCCH format 3, PRACH format 2 and PDCCH.

[14/Xiaomi]

- All scenarios don’t have coverage issue for PUCCH format 1 except GEO set2.
- GEO scenarios have coverage issue for PUCCH format 3

[15/Samsung]

Observation 1: PUCCH format 1 with 2 bits can meet coverage requirement for LEO (set-1/2) and MEO (set-1), however it cannot meet coverage requirement for MEO (set-2) and GEO (set-1/2).

Observation 2: PUCCH format 3 with 11 bits can meet coverage requirement for LEO-600 (set-1/2) and LEO-1200 (set-2), however it cannot meet coverage requirement for LEO-1200 (set-2), MEO (set-1/2), GEO (set-1/2).

Observation 3: PUCCH format 1 with 2 bits may meet the coverage requirement for GEO (set-1) when DM-RS bundling is considered.

[21/Apple]

Observation 5: At 1% BLER, the required SNR for PUCCH is -10.8 dB, -8.4 dB, -6.2 dB and -3.5 dB at repetitions of 8, 4, 2 and 1, respectively.

Observation 6: At 1% BLER, the required SNR for PUCCH format 1 without repetition is -5.8 dB.

Proposal 2: In NR NTN coverage enhancement, PDCCH, PDSCH Msg 2, PDSCH Msg 4 and PUCCH Msg 4 need to be enhanced.

[24/DCM]

Observation 2: Coverage enhancement for PUCCH format 1 is needed for GEO and LEO-1200 with parameter set 2.

Proposal 2: Specify some mechanism for coverage enhancements of PUCCH format 1.

5.5. PRACH

[1/THALES]

Observation 5. For LEO-1200 with SAT Set2 parameters in S band, the achievable SNR for PRACH long format 2 is -21.25dB. The required SNR being equal to -18.5dB, PRACH coverage enhancement is needed: multiple PRACH transmissions within the same beam may be considered as potential technique for NTN coverage enhancement.

Observation 6. For LEO-1200 with SAT Set2 parameters in S band, the gap between the achievable and required SNR is around 8 dB and 10 dB for PRACH format 0 and PRACH format B4 respectively.

Observation 9. For LEO-1200 with SAT Set1 parameters in S band, the achievable SNR for PRACH format 2 is -15.25dB. The required SNR being equal to -18.5dB, no PRACH coverage enhancement is needed for long PRACH format 2.

Observation 10. For LEO-1200 with SAT Set1 parameters in S band, the achievable SNR for PRACH long format 0 is -15.25dB. The required SNR being equal to -13.3dB, PRACH format 0 coverage enhancement is needed: multiple PRACH transmissions within the same beam may be considered as potential technique for NTN coverage enhancement.

Observation 11. For LEO-1200 with SAT Set1 parameters in S band, the achievable SNR for PRACH format B4 is -18.39dB. The required SNR being equal to -14.2dB, PRACH format B4 coverage enhancement is needed: multiple PRACH transmissions within the same beam may be considered as potential technique for NTN coverage enhancement.

Proposal 6: No PRACH coverage enhancement is needed for long PRACH format 2 in NTN.

Observation 14. For LEO-600 with SAT Set2 parameters in S band, the achievable SNR for PRACH format 2 is -15.86dB. The required SNR being equal to -18.5dB, no PRACH coverage enhancement is needed for long PRACH format 2.

Observation 15. For LEO-600 with SAT Set2 parameters in S band, the achievable SNR for PRACH format 0 is -15.85dB. The required SNR being equal to -13.3dB, PRACH format 0 coverage enhancement is needed: multiple PRACH transmissions within the same beam may be considered as potential technique for NTN coverage enhancement.

Observation 16. For LEO-600 with SAT Set2 parameters in S band, the achievable SNR for PRACH format B4 is -19dB. The required SNR being equal to -14.2dB, PRACH format B4 coverage enhancement is needed: multiple PRACH transmissions within the same beam may be considered as potential technique for NTN coverage enhancement.

Proposal 9: No PRACH coverage enhancement is needed in case of LEO-600 with SAT Set1 in S Band based NTN deployment.

[3/HW, HiSi]

Observation 2 : For NTN initial access, PRACH format 2 has smaller coverage gaps compared to format 0 and B4.

Observation 3: For Set-1 LEO-600 satellite, coverage issue for PRACH can be solved by relaxing the requirement of miss-detection rate to about 8%.

Observation 4: For initial access with preamble format 2, when PRACH detection rate is relaxed to 10% within an acceptable increment of random-access delay, LEO-600 satellite with Set-1 setting can provide coverage for PRACH.

- For Set-1 LEO-1200, PRACH would need to be enhanced by 2.7dB with a relaxed PRACH detection rate.

Proposal 1: Prioritize PRACH format 2 for the coverage enhancement for NTN.

Proposal 2: For Set-1 LEO-600 satellite, coverage issue for PRACH can be solved by relaxing the requirement of miss-detection rate or by further enhancements, e.g. further repetitions.

[4/Spreadtrum]

Observation 1: In GEO (i.e., Case 1 and Case 2), there is a large gap between the SNR value required to achieve 1% missed detection at 0.1% false alarm probability of PRACH transmission and the calculated CNR.

Observation 2: In LEO-1200, (i.e., Case 4), the largest gap between the SNR value required to achieve 1% missed detection at 0.1% false alarm probability of PRACH transmission (Format B4) and the calculated CNR is 6dB.

Observation 3: In LEO-600, (i.e., Case 4), the SNR value required to achieve 1% missed detection at 0.1% false alarm probability of PRACH transmission is lower than the calculated CNR.

Proposal 1: Coverage enhancement for PRACH transmission in GEO and LEO-1200 scenarios should be considered.

[6/ZTE]

Observation 1: Enhancement should be considered for legacy PRACH format 2 with following coverage gap:

- Up to 1.32dB gap for LEO-1200 with Set-2.
- Up to 3.6 dB gap for GEO scenario with Set-1.
- Up to 8.38dB gap for GEO scenario with Set-2.

[7/vivo]

Observation 11:

- Maximum performance gap is observed in MEO set-2 scenario for all the 3 PRACH formats.
- For PRACH format 0, up to 14dB and 11dB enhancements are required in LOS condition with 1% and 10% target miss detection rate respectively. (MEO is worse than GEO due to satellite TX power difference between GEO and MEO)
- For PRACH format 2, up to 8dB and 5.1dB enhancements are required in LOS condition with 1% and 10% target miss detection rate respectively.
- For PRACH format B4, up to 14.3dB and 11.4dB enhancements are required in LOS condition with 1% and 10% target miss detection rate respectively.
- Repetitions on top of existing retransmission are being studied in Rel-18 TN coverage enhancement topic for PRACH enhancement.

Proposal 11:

- RAN1 should conclude a target performance gap observed from evaluation of PRACH without repetition or re-transmission in NTN.

[9/MTK]

Proposal 4: Postpone discussions on PRACH enhancements in Rel-18 NTN Enhancements Work Item.

[10/NEC]

Observation-2: Networks may need to configure RACH formats with high number of sequence repetitions (e.g. A3 or B4) in NTN cells for commercial UEs in order to overcome low CINR values

[11/OPPO]

Observation 7: The following physical channels in the initial access have coverage issues in GEO scenario: PRACH, PDCCH, Msg2 PDSCH, Msg3 PUSCH, Msg4 PDSCH and Msg4 PUCCH

Observation 8: The following physical channels in the initial access have coverage issues in LEO scenario due to lack of coverage enhancement techniques: PRACH, Msg4 PDSCH and Msg4 PUCCH.

[12/CATT]

Observation 7: PRACH sequence with length-839 is better than the sequence with length-139 in low SNR case.

Observation 8: In order to adapt to NTN scenerios, it is necessary for PRACH to enhance by repetitions, especially the sequence of length-139.

Observation 9: PRACH format B4 of sequence-139 doesn't match uplink link budget, nevertheless, it is worth doing enhancement due to tolerating larger frequency offset than PRACH of sequence-839.

Proposal 2: PRACH transmission should be enhanced for coeverage enhancement based on simulation results.

[13/Pana]

Proposal 2: Improvement for the following channels should be considered, PUSCH msg3, PUCCH format 3, PRACH format 2 and PDCCH.

[18/Nokia, NSB]

Observation 1. PRACH format 2 has better performance than PRACH format B4 and is closer to the required link budget SNR for single UE scenario.

Observation 2. PRACH format 2 requires larger network overhead compared to PRACH format B4.

Observation 3. PRACH format 2 requires a restricted preamble set to achieve similar performance as PRACH format B4.

Proposal 1. PRACH enhancements should target both PRACH format 2 and PRACH format B4.

[19/QC]

Observation 3: PRACH is a bottleneck channel for supporting low-data rate services over commercial smart phones in NTN.

[24/DCM]

Observation 3: PRACH coverage enhancement is needed for both GEO and LEO-1200.

Proposal 3: Specify some mechanism for PRACH coverage enhancements.

5.6. PDSCH VoIP

[3/HW, HiSi]

Observation 6: If UE implements reception antenna switching, which is allowed by legacy specification, coverage gap of PDSCH with VoIP can be eliminated for LEO-600/1200 under Rural NTN-TDL-A/C.

Observation 13: To support VoIP service, LEO-600 satellite with Set-1 setting can provide the coverage for PDCCH, PDSCH, PRACH and PUSCH for Msg3, but not for PUSCH and PUCCH.

- For LEO-600 with Set-1, PUSCH would need to be enhanced by 3.4 dB, PUCCH format 1 of Msg4 would need to be enhanced by 10dB, and PUCCH format 3 would need to be enhanced by 2.8 dB for VoIP.

- With those enhancements, the coverage for VoIP would also be achieved for all channels for LEO-1200 in NTN-TDL-C with Set-1, and for LEO-600 in NTN-TDL-C with Set-2.

[4/Spreadtrum]

Observation 9: For VoIP, in LEO-1200, (i.e., Case 4), the SNR value required to achieve 2% BLER of PUSCH transmission is lower than the calculated CNR.

Observation 11: For VoIP, in LEO-600, (i.e., Case 7), the SNR value required to achieve 2% BLER of PUSCH transmission is lower than the calculated CNR.

[7/vivo]

Observation 4:

- There is no coverage issue for all studied scenarios to support VoIP on PDSCH.

Proposal 4:

- No enhancement of PDSCH for VoIP is needed in Rel-18 NTN enhancement WI.

[9/MTK]

Observation 2: VoIP cases 3,4,6,7 can be supported with DL aggregation level of up to 8.

[11/OPPO]

Observation 5: VoIP service can be supported in all LEO scenarios for DL and can only be supported in LEO600 set1 for UL.

[21/Apple]

Observation 7: At 2% BLER, the required SNR for PUSCH with VoIP is -12.9 dB with 7 PRBs for 8 repetitions.

[23/Baicells]

Observation 6: For downlink, VoIP, 20 repetitions, 3PRB, rural LOS scenario, 2%BLER, the required SNR is -9.0 dB. The link budget margin is in the range of [-1.4, 5.2]dB.

5.7. PDSCH low-data rate service

[3/HW, HiSi]

Observation 6: If UE implements reception antenna switching, which is allowed by legacy specification, coverage gap of PDSCH with VoIP can be eliminated for LEO-600/1200 under Rural NTN-TDL-A/C.

Observation 7: If UE implements reception antenna switching, the coverage gap of PDSCH with a low data rate 1 Mbps could be further eliminated for LEO-600/1200 under Rural NTN-TDL-A/C.

Observation 14: Both set-1 and set-2 LEOs can provide coverage for PDSCH with a low data rate of 1Mbps.

[4/Spreadtrum]

Observation 8: For Low-data rate service, in GEO (i.e., Case 1 and Case 2), the gap between the SNR value required to achieve 10% BLER of PDSCH transmission and the calculated CNR is 1.39dB.

Observation 10: For Low-data rate service, in LEO-1200 (i.e., Case 5), the SNR value required to achieve 10% BLER of PUSCH transmission is lower than the calculated CNR.

[7/vivo]

Observation 5:

- For PDSCH 3kbps data rate, no coverage issue is observed.

- For PDSCH 1Mbps data rate in LOS condition, 3.78dB and 4.96dB performance gap can be observed under MEO set-2 cases and GEO set-2 cases, respectively.

Proposal 5:

- Focus on 3kbps data on PDSCH and no enhancement is needed in this case.
- 1Mbps data on PDSCH should be focused on only for set-1 satellites.

[9/MTK]

Observation 3: For low data rate service cases with EIRP density values in table 6.1.1.1-1/2 of TR38.821 for GEO/LEO-1200/LEO-600 and S-band with bandwidth 10 MHz, up to 500 kbps can be achieved for LEO cases 5, 8, and GEO case 1.

Proposal 1: Re-use Rel-15 DL slot aggregation level up to 8 for Rel-18 NR NTN coverage enhancement.

[11/OPPO]

Observation 4: 1Mbps DL data rate can be supported in GEO set1 and LEO. 400kbps DL data rate can be achieved in GEO set2 when the number of allocated RBs is 100.

[12/CATT]

Observation 11: PDSCH can achieve a BLER 10-1 and meet requirements of set-1 link budgets except to GEO by exsiting R17 CE technologies based on NTN-TDL-C at without PFD limitation case.

[14/Xiaomi]

- All scenarios have coverage issue for 100kbps service in UL, DL with low MCS is okay if PFD not considered.

[21/Apple]

Observation 8: At 10% BLER, the required SNR for PDSCH with 3 kbps is -10.5 dB with 1 PRB and 120/1024 coding rate with 8 repetitions.

Observation 9: At 10% BLER, the required SNR for PDSCH with 1 Mbps is -7.1 dB with 40 PRBs and 120/1024 coding rate without repetition.

[23/Baicells]

Observation 7: For downlink, low data rate service, 3kbps, 32 repetitions, coding rate = 0.25, rural LOS scenario, 10%BLER, our simulation result is that the required SNR is -13.0dB. The link budget margin is in the range of [-3.3, 4.2]dB. For example, for case 2 (GEO, set2), link budget margin is negative (-3.3dB).

Observation 8: For downlink, low data rate service, 1Mbps, 8 repetitions, coding rate = 0.17, rural LOS scenario, 10%BLER, our simulation result is that the required SNR is -11.0dB. The link budget margin is in the range of [-5.3, 2.4]dB. For example, for case 2 (GEO, set2), link budget margin is -5.3dB.

5.8. Msg2 PDSCH / Msg4 PDSCH

[3/HW, HiSi]

Observation 8: If UE implements reception antenna switching, which is allowed by legacy specification, coverage gap of PDSCH Msg. 4 could be eliminated for LEO-600/1200 under Rural NTN-TDL-A/C, and could be further eliminated for Set-1 GEO under Rural NTN-TDL-A/C.

[7/vivo]

Observation 6:

- For Msg2, no coverage issue is identified in any scenarios except GEO set-2.
- For Msg4, 0.23 dB to 7.38 dB performance gap is observed for all scenarios (except LEO set 1) in LOS condition.
- Multiple Msg4 transmissions can be scheduled by gNB independently.

Proposal 6:

- No enhancement of PDSCH for Msg2 is needed in Rel-18 NTN enhancement WI.
- No enhancement of PDSCH for Msg4 is needed in Rel-18 NTN enhancement WI.

[11/OPPO]

Observation 7: The following physical channels in the initial access have coverage issues in GEO scenario: PRACH, PDCCH, Msg2 PDSCH, Msg3 PUSCH, Msg4 PDSCH and Msg4 PUCCH

Observation 8: The following physical channels in the initial access have coverage issues in LEO scenario due to lack of coverage enhancement techniques: PRACH, Msg4 PDSCH and Msg4 PUCCH.

[21/Apple]

Observation 10: At 10% BLER, the required SNR for Msg2 PDSCH is -6.4, -9.1 and -11.6 dB with 3PRBs, 3DMRS symbols and 120/1024 coding rate with scaling factor of 1, ½ and ¼ , respectively.

Observation 11: At 10% BLER, the required SNR for Msg4 PDSCH is -6.7 dB or -9.5 dB with 37 PRB and 120/1024 coding rate with repetitions of 1 and 2, respectively.

Proposal 2: In NR NTN coverage enhancement, PDCCH, PDSCH Msg 2, PDSCH Msg 4 and PUCCH Msg 4 need to be enhanced.

5.9. PDCCH

[3/HW, HiSi]

Observation 9: If antenna selection of two antennas among the 4 antennas on the smart phone is utilized, the coverage gap of PDCCH during initial access/in IDLE mode can be further eliminated.

[7/vivo]

Observation 3:

- For PDCCH, in LOS condition, 2.53dB and 3.81 dB performance gap are observed for MEO and GEO set 2 satellites, respectively.

Proposal 3:

- Focus on cases of LEO, MEO satellites, or GEO set-1 satellites.
- No enhancement of PDCCH is needed in Rel-18 NTN enhancement WI.

[12/CATT]

Observation 10: PDCCH can achieve a BLER 10-2 and meet requirements of set-1 link budgets by exsiting R17 CE technologies based on NTN-TDL-C in without PFD limitation case.

[13/Pana]

Proposal 2: Improvement for the following channels should be considered, PUSCH msg3, PUCCH format 3, PRACH format 2 and PDCCH.

[21/Apple]

Observation 12: At 1% BLER, the required SNR for PDCCH is -10.2 dB at aggregation level of 16.

Proposal 2: In NR NTN coverage enhancement, PDCCH, PDSCH Msg 2, PDSCH Msg 4 and PUCCH Msg 4 need to be enhanced.

[22/LGE]

Proposal 1. Unicast PDCCH should be de-prioritized from candidate physical radio channels for the NTN CE.

5.10. SSB

[7/vivo]

Observation 2:

- For SSB transmission, 3.56dB to 5.64dB performance gap is observed in NLOS condition for MEO and GEO set 2 satellites.
- For SSB transmission, PBCH cannot meet the link budget requirement in LOS condition for GEO set 2 satellites.

Proposal 2:

- In case of GEO case, focus on studying GEO set 1 satellite and de-prioritize GEO Set-2.
- No enhancement of SSB in Rel-18 NTN enhancement WI.

[12/CATT]

Proposal 4: SSB transmission should be enhanced with reptitions even without PFD limitation.

5.11. PFD limit

[6/ZTE]

Observation 5: With the consideration of ITU regulation of PFD limitation, CNR limitations corresponding to GEO and LEO are as follows:

- -16.8 dB CNR limitation for GEO corresponding to 25 degree to 90 degree elevation angle.
- -11.8 dB CNR limitation for LEO corresponding to 25 degree to 90 degree elevation angle.

Observation 6: Coverage enhancement should be considered for SSB due to the coverage gap as:

- 3.2dB coverage gap for GEO.

Observation 7: With the consideration of ITU regulation of PFD limitation, coverage enhancement should be considered for PDCCH due to the huge coverage gap as:

- 5.8 dB coverage gap compared with the CNR limitation of GEO.
- 0.8 dB coverage gap compared with the CNR limitation of LEO.

Observation 8: With the consideration of ITU regulation of PFD limitation, coverage enhancement should be considered for Msg.2 due to the huge coverage gap as:

- 7.3 dB coverage gap compared with the CNR limitation of GEO.
- 2.3 dB coverage gap compared with the CNR limitation of LEO.

Observation 9: With the consideration of ITU regulation of PFD limitation, coverage enhancement should be considered for Msg.4 due to the huge coverage gap as:

- 9.3 dB coverage gap compared with the CNR limitation of GEO.
- 4.3 dB coverage gap compared with the CNR limitation of LEO.

Observation 10: With the consideration of ITU regulation of PFD limitation, there is no coverage gap for VoIP service with reusing the NR PDSCH aggregation mechanism.

Observation 11: With the consideration of ITU regulation of PFD limitation, there is no coverage gap for low data rate service with reusing the NR PDSCH aggregation mechanism.

[11/OPPO]

Observation 9: When PFD limitation is considered, the following DL physical channels have coverage issues and further enhancement is needed: DL VoIP service, DL low data rate service, Msg2 PDSCH, Msg4 PDSCH and PDCCH.

[14/Xiaomi]

- All scenarios have coverage issue for3 kbps if PFD considered

Proposal 4: Note 3 of ITU regulation should be clarified before study the PFD impact.

[17/ETRI]

Observation: If the PFD limit is applied, EIRP and CNR are very low.

Proposal 2: If the PFD limit should be met, discussions on how to increase the CNR will be required.

[21/Apple]

Proposal 1: In the evaluation of the NR NTN coverage performance, the satellite EIRP density is adjusted to satisfy ITU regulation of PFD limitation.

- With the consideration of ITU regulation of PFD limitation, the satellite EIRP density is adjusted to 44 dBW/MHz, 20 dBW/MHz and 14 dBW/MHz in GEO, LEO-1200, LEO-600, respectively.

[24/DCM]

Observation 4: PDCCH coverage enhancement is needed for both GEO and LEO-1200 only if PFD regulation are to be considered.

Proposal 4: RAN1 should discuss further whether to consider PFD regulation.

[25/Ericsson]

Proposal 1 For evaluation of DL coverage, consider the PFD limitation value of -108 dBW/m2 given in ITU Resolution 212 (Rev. WRC 19).

Proposal 2 For evaluation of DL coverage, consider both the EIRP values given in TR 38.821 and EIRP values derived from the PFD limitation value from ITU resolution 212 (Rev. WRC 19).

Observation 5 There is no satellite configuration (GEO/MEO/LEO with Set-1/Set-2) for which the targets are reached for all downlink channels with PFD limitation.

5.12. Scenarios to be considered

[1/THALES]

Proposal 2: RAN1 to discuss whether to support LEO-1200 with SAT Set2 parameters in S band for NR NTN, by taking into account the specification impact that may be needed to tackle the coverage bottleneck in such deployment scenario.

[3/HW, HiSi]

Observation 10: Set-2 satellite faces too large coverage gap, which seems difficult to be eliminated by standard work.

Proposal 3: Prioritize the coverage enhancement for Set-1 satellite.

Observation 11: Compared to LEOs 600 almost all channels face up to 10 dB coverage gap for GEO cases.

Proposal 4: Prioritize the coverage enhancement for LEOs.

Observation 12: LOS channel is the majority cases (larger than 90%) for UEs served by LEOs in rural scenarios.

Proposal 5: Prioritize the coverage enhancement to cover NTN-TDL-C channels.

[7/vivo]

Observation 1:

- 18.42 dB CL for 30° elevation angle, 18.17 dB CL for 20° and 19.52 dB CL for 10° in rural scenarios should be considered for NLOS in coverage performance evaluation.

Proposal 1:

- Focus on the LOS condition in NTN coverage enhancement study.

Proposal 13:

- In Rel-18 NTN coverage enhancement work item, LOS condition should be assumed and prioritize following services:
- 4.75kbps VoNR service for LEO-600 satellites or LEO-1200 set-1 satellites.
- 3kbps data service in uplink for LEO satellites or MEO set-1 or GEO set-1 satellites.
- 1Mbps data service in downlink for set-1 LEO/MEO/GEO satellites.

[9/MTK]

Proposal 2: De-prioritize TDL-A (NLOS) in Rel-18 NTN Coverage enhancement WI.

Proposal 3: De-prioritize LEO-1200 set 2 and GEO set 1 and set 2.

[12/CATT]

Observation 1: There are bad CNR results in the scenarios of GEO, especially set-2 scenarios, and the uplink link budget is worse than downlink link budget.

Observation 2: The link budget results for downlink are unrelated to the bandwith.

Proposal 1: Deprioritize GEO scenarios and Set-2 for NTN handset case.

[13/Pana]

Proposal 1: Clarify the deployment scenarios, satellite parameter sets and channel conditions to be supported for the respective service. Our view is as follows

- NLOS condition and satellite parameter set 2 are low priority.
- For GEO and MEO, UL 3kbps and DL 1Mbps should be supported at least LOS and satellite parameter set 1.
- For LEO, UL 3kbps, DL 1Mbps and VoIP should be supported for LOS and NLOS at least parameter set 1

- PUSCH 100kbps is not supported.

[14/Xiaomi]

Proposal 2: Coverage enhancement for GEO Set 2 is not considered.

[18/Nokia, NSB]

Observation 4. It may be difficult to close the reported link budgets for LEO-600 and LEO-1200 scenarios with PHY-only techniques and enhancements. One direction for further investigation would be to consider the improvement of link budget together with PHY coverage enhancement techniques.

Observation 5. Restricting the range of minimum elevation angles supported for different service applications improves the link budget performance and increases the likelihood of closing the corresponding link budget by PHY coverage enhancement techniques.

Proposal 2. RAN1 to consider and discuss options for improving the link budget of UL NR NTN at least for PUSCH, e.g., by increasing UE antenna gain and/or restricting the minimum elevation angles of considered scenarios.

Observation 6. Link level performance of both GEO Set1 and GEO Set2 reveals that it may be difficult to achieve the required link budget SNRs for 10% BLER. One further investigation direction could be to improve the link budget performance, and consequently, together with PHY enhancement techniques achieve the desired link budget SNRs.

Proposal 3. RAN1 may consider prioritizing GEO-Set1 over GEO-Set2 for PUSCH coverage enhancement.

[23/Baicells]

Observation 1: For NTN link budget, GEO / satellite parameter set-2 are more severe scenarios comparing with LEO / satellite parameter set-1.

Proposal 1: For NTN downlink, GEO coverage needs enhancement.

[24/DCM]

Proposal 5: RAN1 should discuss whether to support satellites with parameter set 2.

[25/Ericsson]

Observation 2 There is no satellite configuration (GEO/MEO/LEO) for which the targets are reached for all uplink channels.

Observation 3 For LEO-600 Set-1, the performance targets for most uplink channels are reached.

Observation 4 For GEO and MEO, none of the performance targets for uplink are reached.

Observation 6 Without PFD limitation, the performance targets are reached for all evaluated channels for LEO with Set-1 and MEO with Set-1.

5.13. On simulation assumptions

- [1/THALES] RAN1 to discuss whether other values for the K factor and the delay spread may be more appropriated for the study.
- [5/NTPU] Proposal 2: 3dB loss for link budget calculation due to the HPBW at beam edge should be discussed.
- [16/ITL] Proposal 2: it is beneficial to check whether the legacy coverage enhancement schemes is applicable to NTN or not based on evaluations specific to the NTN channel conditions and scenarios.

- [22/LGE] Proposal 3. It is necessary to discuss whether to support the DMRS bundling in Rel-18 NTN for joint channel estimation.
- [15/Samsung] Proposal 1: RAN1 needs to further discuss satellite receive antenna gains and conclude on a realistic value range at least for GEO satellites in order to recommend whether or not further PUCCH enhancements are needed for NR NTN.

5.14. Potential techniques

- Common for DL/UL
  - [2/Lockheed] Consider the use of 2x2 polarization pre-coding for the CP-OFDM and DFT-s-OFDM waveforms.
  - [3/HW, HiSi] Proposal 7: Study polarization diversity to enhance the coverage of NR NTN.
  - [8/Sony] Proposal 7: RAN1 can study how network can obtain the UE capabilities on supported polarization modes in Rel-18.
  - [8/Sony] Proposal 8: RAN1 should study inter-user multiplexing over the polarization domain in Rel-18.
  - [8/Sony] Proposal 9: RAN1 should study polarization indication per beam in Rel-18.
  - [20/Lenovo] Proposal 7: Study the association between polarization mode and RS.
  - [20/Lenovo] Proposal 9: Study the impact of CSI prediction on system performance in NLOS channel conditions.
- UL
  - [8/Sony] Proposal 1: RAN1 should study configuration of UL waveform switching from CP-OFDM to DFT-s-OFDM for UEs in need of coverage enhancement.
  - [8/Sony] Proposal 2: Study more accurate UE beamforming for coverage enhancement of the NTN UL.
  - [8/Sony] Proposal 3: Study the impact of configuration of small transmission bandwidths for enhancement of the NTN UL coverage.
  - [8/Sony] Proposal 4: Study the use of repeat transmissions with increased number of repetitions and impact of incremental redundancy for the low code rates typical of NTN in the enhancement of the NTN UL coverage, while considering making repetition resilient when there are TA changes (and Doppler changes) during the ongoing sets of repetitions
  - [20/Lenovo] Proposal 1: Updated K-offset MAC CE is applied at the start of the first repetition of an uplink channel. Proposal 4: Application of updated K-offset is only at the start of the joint channel estimation window.
  - [20/Lenovo] Proposal 3: A TA update can be considered as an event to terminate the joint channel estimation window.
  - [20/Lenovo] Proposal 8: Study the polarization based scheme for uplink initial access channels.
  - [22/LGE] Proposal 7. It is necessary to discuss how to support changing open loop TA (e.g., UE specific TA and/or common TA) during repeated transmission of UL signal/channel in Rel-18 NTN.
  - [22/LGE] Proposal 8: If antenna polarization configuration of gNB are provided to UE, It would be necessary to discuss how to consider the antenna polarization for open-loop UL power control.
  - PUSCH

- [3/HW, HiSi] Proposal 9: Study lower DM-RS density in the frequency domain with power boosting for PUSCH coverage enhancement.
- [6/ZTE] Proposal 3: Following approaches can be considered to optimize the coverage of PUSCH for VoIP:
  - JCE with without FO based on pre-compensation for UL transmission
  - Polarization matching between UE and gNB to overcome the polarization loss.
- [7/vivo] For PUSCH 3kbps data rate, increasing repetition number beyond 32 should be de-prioritized.

- PUSCH Msg.3
  - [6/ZTE] Proposal 2: Following approaches can be considered to optimize the coverage of Msg3
    - More repetitions (e.g., 32)
    - JCE without FO should be guaranteed for Msg-3 transmission based on the pre-compensation mechanism.
  -
- PUCCH
  - [7/vivo] PUCCH repetition for UEs in RRC idle/inactive state.
  - [15/Samsung] Proposal 2: If RAN1 concludes that PUCCH transmission should be improved to enhance coverage, consider larger numbers of repetitions for PUCCH (e.g., 16/32 repetitions).
- PRACH
  - [1/THALES] Proposal 7: RAN1 to discuss the two options below:
    - Option 1: Only PRACH format 2 is supported in LEO-1200 based NTN deployment with SAT Set1 parameters and no PRACH coverage enhancement is needed.
    - Option 2: multiple PRACH transmissions within the same beam may be considered as potential technique for NTN coverage enhancement to support PRACH format 0 and format B4 in in LEO-1200 based NTN deployment with SAT Set1 parameters
  - [3/HW, HiSi] Proposal 10: Discuss whether the detection performance of a single-shot PRACH preamble can be relaxed for coverage enhancement.
  - [4/Spreadtrum] Proposal 4: Beam-level repetition value configuration of PRACH can be considered.
  - [4/Spreadtrum] Proposal 4: Repetitions enhancements for 2-Step RACH should be considered in R18 for smart phones in NTN.
  - [6/ZTE] Proposal 1: Following approaches can be considered to optimize the coverage of PRACH format 2 for GEO
    - Larger repetitions (e.g., 16).
    - Polarization matching between UE and gNB to overcome the polarization loss.
  - [7/vivo] PRACH repetition
  - [10/NEC] Proposal-1: At least two sets of RACH resources are required to be configured with different RACH formats or repetitions, to allow both VSAT UEs and commercial UEs gain access to NTN cell

- [10/NEC] Proposal-2: Discuss how to configure multiple RACH resource sets per cell for initial random-access procedure
  - Option-1: Configure two separate UL cells (similar to SUL and NUL) to allow configuring different set of RACH resources for commercial UEs and VSAT UEs
  - Option-2: Configure two sets of RACH resources with different RACH formats/repetitions within initial active BWP
- [22/LGE] Proposal 5. If repeated transmission of PRACH preamble is supported in Rel-18 NTN, RAN1 should consider to discuss at least followings
  - Maximum repetition number
  - RA-RNTI
  - RAR window starting point
- [22/LGE] Proposal 6. For NTN coverage enhancement, it should be considered to configure exclusive RACH occasion for low power class UE suffering high path loss.
- [12/CATT] PRACH repetitions can be achieved by configuring multiple consecutive random access occasions in applications, with configurable 1,2,4,8,16 consecutive random access occasions.
- [19/QC] Proposal 2: For PRACH format 2 in NTN, antenna switching point is CP/2 before the end of the second repletion or 22232x64 Tc of the second repetition.
-

- DL
  - [2/Lockheed] Consider use of DFT-s-OFDM for downlink transmissions.
  - [7/vivo] Circular polarization enhancement on Tx diversity could be further studied for downlink transmissions.
  - [8/Sony] Proposal 5: Study the adoption of DFT-s-OFDM configurability for coverage enhancement of the NTN DL.
  - [8/Sony] Proposal 6: RAN1 should enhance the polarization support for Rel-18 to improve the coverage of NTN.
  - SSB
    - [6/ZTE] Proposal 5: Following coverage enhancements should be considered for SSB:
      - Increase the number of Rx antenna.
      - Shorten the assumed SSB period from 20ms to 10ms in cell search
      - Enable the joint processing cross adjacent SSBs with different index
      - Enable the SSB transmission with single index per duration
    -
  - PDSCH
    - [4/Spreadtrum] Proposal 5: Larger aggregation factor for PDSCH transmission should be considered in R18 for smart phones in NTN.
    - [6/ZTE] Proposal 7: Enhanced Msg.2 with repetitions should be supported in NR NTN.

- [6/ZTE] Proposal 8: Enhanced Msg.4 with repetitions, such as 16 or more, should be supported in NR NTN.

- PDCCH
  - [6/ZTE] Proposal 6: Following coverage enhancements should be considered for PDCCH:
    - Increase the size of REG bundle.
    - Increase aggregation level.
    - Increase the number of Rx antenna.
    - Support repetitions of PDCCH.

- Others
  - [7/vivo] Send an LS to RAN2 to ask the maximum RAN protocol overhead that can be reduced for voice packet transmission in NR NTN with a reasonable complexity.
  - [19/QC] Proposal 1: RAN1 asks RAN2 to investigate mechanisms to enable application-layer voice frame aggregation.

6. References

[1] R1-2205826 Discussion on NR NTN coverage enhancement THALES

[2] R1-2205832 Coverage Enhancement for NTN Lockheed Martin

[3] R1-2205856 Discussion on coverage enhancement for NR NTN Huawei, HiSilicon

[4] R1-2206009 Discussion on coverage enhancements for NTN Spreadtrum Communications

[5] R1-2206012 Coverage enhancement for NR NTN NTPU

[6] R1-2206020 Discussion on coverage enhancement for NTN ZTE

[7] R1-2206063 Discussions on coverage enhancement for NR NTN vivo

[8] R1-2206133 Considerations on improving NR NTN Coverage Sony

[9] R1-2206137 Coverage enhancement for NR NTN MediaTek Inc.

[10] R1-2206236 Discussion on coverage enhancements aspects for NR NTN NEC

[11] R1-2206310 Discussion on coverage enhancement for NR NTN OPPO

[12] R1-2206386 Discussion on coverage enhancement for NR NTN CATT

[13] R1-2206423 Evaluation results for NTN coverage enhancement Panasonic

[14] R1-2206630 Discussion on coverage enhancement for NR-NTN Xiaomi

[15] R1-2206848 On coverage enhancement for NR NTN Samsung

[16] R1-2206859 On NTN coverage enhancement ITL

[17] R1-2206961 Coverage enhancement for NR NTN ETRI

[18] R1-2207140 Evaluation of coverage enhancements for NR over NTN Nokia, Nokia Shanghai Bell

[19] R1-2207255 Coverage enhancements for NR NTN Qualcomm Incorporated

[20] R1-2207294 Discussion on coverage enhancement for NR NTN Lenovo

[21] R1-2207353 Performance Evaluation on Coverage Enhancement for NR NTN Apple

[22] R1-2207358 Discussion on coverage enhancement for NR NTN LG Electronics

[23] R1-2207372 Discussion on coverage enhancement for NR NTN Baicells

[24] R1-2207428 Discussion on coverage enhancement for NR NTN NTT DOCOMO, INC.

[25] R1-2207556 On coverage enhancements for NR NTN Ericsson

7. Appendix-1 (Copy from WID RP-221819)

4.1 Objective of SI or Core part WI or Testing part WI

The work item aims at specifying enhancements for NG-RAN based NTN (Non-Terrestrial Networks) according to the following assumptions with implicit compatibility to support HAPS (High Altitude Platform Station) and ATG (Air To Ground) scenarios:

- GSO (Geo Synchronous Orbit) and NGSO (Non Geo Synchronous Orbit). NGSO includes Low Earth Orbit (LEO) and Medium Earth Orbit (MEO).
- Earth fixed tracking area. Earth fixed & Earth moving cells for NGSO
- FDD mode
- UEs with GNSS (Global Navigation Satellite Systems) capabilities
- Both “VSAT” (Very Small Aperture Terminal) devices with directive antenna (including fixed and moving platform mounted devices and commercial handset terminals (e.g. Power class 3) are supported in FR1
- Only “VSAT” devices with directive antenna (including fixed and moving platform mounted devices) are supported in above 10 GHz bands.

Note 1: In Rel-17 WID, “VSAT” device with external antenna on moving platform is equivalent to a device that operate on platforms in motion, and this is referred to as ESIM (Earth Station In Motion).

Note 2: The Rel-17 NTN architecture is assumed.

The detailed objectives are to specify enhancing features to Rel-15, 16 & 17’s NR radio interface & NG-RAN as follows:

4.1.1 Coverage enhancement

The Rel-18 NTN objectives are focused on the applicability of the solutions developed by general NR coverage enhancement to NTN, and identifying potential issues and enhancements if necessary, considering the NTN characteristics including large propagation delay and satellite movement. Only NTN-specific characteristics are to be included in this coverage enhancement work, otherwise it should be part of another WI (e.g., UL enhancement of coverage). The work needs to cover the use case of voice and low-data rate services using commercial smartphones with more realistic assumptions on antenna gains instead of 0dBi currently assumed for link budget analysis for non-terrestrial networks. The specific realistic antenna gain assumption will be determined at the working group level. The evaluation should also take into account any related regulatory
requirements, e.g., ITU limitation of power flux density.

Have a 1-TU 6-month study phase focusing on the following (to derive clear & limited scope):

- Evaluate the coverage performance and identify the candidate physical radio channels that have coverage issues specific to NTN with following target services taking into account the studies in TR38.830 where appropriate, as well as general

coverage enhancement techniques specified in Rel-18 [RAN1,RAN2,RAN4]
    - VoIP and low-data rate services for commercial handset terminals

The following items are shown as examples of areas to consider in the next step of the study. The actual items for study will be based on the evaluation of coverage issues specific to NTN identified above.

- NTN-specific repetitions enhancements beyond techniques covered in Rel-17 CovEnh WI for the relevant channels
- NTN-specific techniques for improved diversity and/or reduced polarization loss
- Improved performance of low-rate codecs in link budget limited situation including reducing RAN protocol overhead for VoNR
    - NOTE: Intent is not to introduce a new codec.

RAN to determine by RAN#97 (for RAN1 items) and RAN#98 (for RAN2 items) whether the study phase has identified any need for NTN-specific coverage enhancements in Rel-18. If needed, the set of NTN-specific work item objectives will be updated.

8. Appendix-4 (Outcomes of post meetings)

RAN1#109-e

Agreement

For NR NTN coverage enhancement, evaluate only handset terminals as UE type.

- i.e., VSAT is not considered.

Agreement

Coverage performance in NR NTN is evaluated according to the following steps.

- Step 1: CNR is calculated as defined in 6.1.3.1 of TR38.821
    - For polarization loss,
        - 3 dB polarization loss is assumed as baseline, and companies are encouraged to report the value and corresponding justification if other value is used
- Step 2: Required SNR of target service is evaluated by LLS
- Step 3: The CNR and the required SNR are compared

Agreement

Coverage performance in NR NTN is evaluated for GEO/LEO-1200/LEO-600 scenarios.

- Note: Service type for each scenario is discussed separately
- Note: Parameter set (Set-1/2) is discussed separately
- Note: MEO can be evaluated optionally

Agreement

For evaluation of coverage performance in NR NTN,

- It is assumed that carrier bandwidth is sufficiently large to transmit each channel.
- Companies are encouraged to report BWP bandwidth, when necessary (e.g. for frequency hopping).
- Note: each channel bandwidth is discussed separately.

Agreement

For VoIP, AMR 4.75 kbps (TBS of 184 bits without CRC in physical layer) with 20 ms data arriving interval is used in the evaluations.

- Each packet is transmitted within 20 ms, if packet combining is not used.
    - Companies are encouraged to evaluate at least packet transmission without combining
    - Companies are encouraged to report how to apply packet combining, if used.
    - Note: in packet combining, two packets can be combined into a single packet at TX side
        - Companies should report the impact on E2E latency
- VoIP is evaluated only in LEO scenario.
- Note 1: PRB/MCS/TBS determinations are discussed separately
- Note 2: companies should report if HARQ is used in the evaluations, and if evaluations depart from the assumption that each packet is transmitted within 20 ms

Agreement

Reuse Set-1/2 satellite parameters as in table 6.1.1.1-1/2 of TR38.821 for GEO/LEO-1200/LEO-600 and S-band, and as in table 6.1.1.1-1/2 of RP-220590 for MEO and S-band.

- In addition, evaluations assuming relevant ITU regulatory limitations on power flux density can be reported in the study phase.
    - Companies should report which value of EIRP density is used and corresponding justification.

Agreement

For link budget calculation, parameters in the following table is assumed.

Parameters	Notes
Carrier frequency	2 GHz for DL and UL (S-band)
Channel bandwidth	FFS
Satellite altitude	600 km, 1200 km, 10000 km, 35786 km
Target elevation angle	[30° (LEO), 12.5° (GEO-Set 1) , 20° (GEO –Set 2), 30° (MEO)]
Atmospheric loss	Equation (6.6-8) in [2]
Shadowing margin	3 dB
Scintillation loss	Section 6.6.6 in [2]

	Ionospheric loss: A_{IS} = 2.2 dB (note 1) Tropospheric loss: Table 6.6.6.2.1-1 of [2]
Additional loss	0 dB
Clear sky conditions	Yes
Satellite antenna polarization	Circular polarization
Terminal type	[S band: (M, N, P) = (1,1,2)]
Free space path loss	Equation (6.6-2) in [2]
Terminal RF parameters	FFS
Satellite RF parameters	FFS
Polarization loss	As agreed separately
Outcome	CNR

- NOTE 1: Based on P3 curve for 1% of time from Figure 6.6.6.1.4-1 of [2] after frequency scaling.
- $A_{IS} = Pfluc@\,4GHz \times 0.5^{-1.5} / \sqrt{2} = 1.1 \times 0.5^{-1.5} / \sqrt{2} = 2.2$ dB
- NOTE 2: [2] in this table is 3GPP TR 38.811 v15.2.0: "Study on New Radio (NR) to support non-terrestrial networks (Release 15)"

Agreement

If corresponding channel (including SCS) is agreed as evaluation target channel, the following features introduced in Rel-17 Coverage enhancement WI can be applied in coverage evaluation of NR NTN.

- For VoIP, max 20 PUSCH repetitions if SCS = 15 kHz and packet combining/HARQ are not applied; otherwise, max 32 PUSCH repetitions with consideration of the impact on E2E latency
- For low-data rate service, max 32 PUSCH repetitions
- TBoMS
- Joint channel estimation (DMRS bundling)
  - Companies are encouraged to report how to apply
- Max 16 Msg.3 PUSCH repetitions

Agreement

For low-data rate service, the following target data rate is assumed.

- For DL, 3 kbps if satellite EIRP density lower than values in table 6.1.1.1-1/2 of TR38.821 for GEO/LEO-1200/LEO-600 and S-band, or values in table 6.1.1.1-1/2 of RP-220590 for MEO and S-band due to ITU regulatory limitations on power flux density is considered; otherwise, 1 Mbps
- For UL, 3 kbps and 100 kbps
  - FFS: which data rate applies for GEO/MEO/LEO

Agreement

For NR NTN coverage enhancement, the following channels/signals can be evaluated.

- PUSCH for VoIP
- PUSCH for low data rate service
- PUCCH format 1 with 2 bits
- PUCCH format 3 with 11 bits
- PRACH format 0
- PRACH format 2
- PRACH format B4
- PUSCH Msg.3
- PUCCH for Msg.4 HARQ-ACK
- SSB
- PDSCH for VoIP
- PDSCH for low data rate service
- PDSCH Msg.2
- PDSCH Msg.4
- PDCCH
- Broadcast PDCCH (PDCCH of Msg.2)

Agreement

Evaluate coverage performance for the following UE characteristics as in Table 6.1.1.1-3 of TR38.821 with update of polarization, Tx/Rx antenna gain, and antenna type and configuration.

Characteristics	Handheld
Frequency band	S band (i.e. 2 GHz)
Antenna type and configuration	1 TX, 2TX (optional) / 2 RX with omni-directional antenna element Note: companies should provide their assumption on polarization
Polarisation	Linear
Rx Antenna gain	[X] dBi per element
Antenna temperature	290 K
Noise figure	7 dB

Tx transmit power	200 mW (23 dBm)
Tx antenna gain	[X] dBi per element

- X = -5 as working assumption
  - ➢ Send an LS to RAN4 to ask whether above antenna gain is valid and if invalid, appropriate value.

R1-2205622 [Draft] LS on UE antenna gain for NR NTN coverage enhancement Moderator (NTT DOCOMO, INC.)

R1-2205623 LS on UE antenna gain for NR NTN coverage enhancement RAN1, NTT DOCOMO, INC.

Final LS is endorsed in R1-2205623.

Agreement

For coverage performance evaluation, the following elevation angle is assumed.

- 30 deg for LEO, 12.5 deg for GEO-Set 1, 20 deg for GEO-Set 2, as in in Table 6.1.3.2-1 of TR38.821
  - Note: For GEO-Set 1, channel parameters for 10 deg is used in LLS.
- 30 deg for MEO
- Other elevation angles can be evaluated as optional
- Note: these values are elevation angles at the edge of the edge beam.

Agreement

For NR NTN coverage enhancement, evaluate the following cases.

Case	Satellite orbit	Satellite parameter set	Elevation angle (deg)	Terminal	Frequency band	Service type
1	GEO	1	12.5	Handset	S-band	Low-data rate service
2	GEO	2	20	Handset	S-band	Low-data rate service
3 (Optional)	LEO-1200	1	30	Handset	S-band	VoIP
4	LEO-1200	2	30	Handset	S-band	VoIP
5	LEO-1200	2	30	Handset	S-band	Low-data rate service
6 (Optional)	LEO-600	1	30	Handset	S-band	VoIP
7	LEO-600	2	30	Handset	S-band	VoIP
8 (Optional)	LEO-600	2	30	Handset	S-band	Low-data rate service

9 (Optional, with higher priority than case 10)	MEO	1	30	Handset	S-band	Low-data rate service
10 (Optional)	MEO	2	30	Handset	S-band	Low-data rate service

Agreement

For coverage performance evaluation, the following are assumed for all channels/signals

- Channel model/Delay spread
  - Channel model as in Table 6.1.2-4 of TR38.821, assuming NTN-TDL-A (NLOS) and NTN-TDL-C (LOS)
- Evaluation scenario
  - Rural (LOS/NLOS)
  - Sub-urban (LOS/NLOS) (optional)
- Channel estimation: Realistic estimation
  - Companies are encouraged to report channel estimation method.
- SCS
  - 15 kHz only
- UE speed: 3 km/h
- Frequency drift: Not assumed
- Frequency offset: 0.1 ppm

Agreement

For coverage evaluation of PUSCH in NR NTN, the following table is assumed.

Parameter	Value
Frequency hopping	w/ or w/o frequency hopping
BLER	For low data rate service, w/ HARQ, 10% iBLER; w/o HARQ, 10% iBLER. For VoIP, 2% rBLER.
Number of UE transmit chains	1, 2 (optional)
DMRS configuration	For 3km/h: Type I, 1 or 2 DMRS symbol, no multiplexing with data. For frequency hopping: Type I, 1 or 2 DMRS symbol for each hop, no multiplexing with data. PUSCH mapping Type, the number of DMRS symbols and DMRS position(s) are reported by companies.

Waveform	DFT-s-OFDM, CP-OFDM (optional)
PUSCH duration	14 OS
Repetitions	w/ type A repetition, optional for type B repetition. The actual number of repetitions is reported by companies.
HARQ configuration	Whether/How HARQ is adopted is reported by companies.
PRBs/TBS/MCS for low data rate service	Any value of PRBs, and corresponding MCS index, reported by companies will be considered in the discussion. TBS can be calculated based on e.g. the number of PRBs, target data rate, frame structure and overhead.
PRBs/MCS for VoIP	Any value of PRBs reported by companies will be considered in the discussion. QPSK, pi/2 BPSK (optional)
Other parameters	Reported by companies

Agreement

For coverage evaluation of PUCCH in NR NTN, the following table is assumed.

Parameter	Value
PUCCH format	Format 1, 2bits UCI. Format 3, 11 bits UCI
Frequency hopping	w/ frequency hopping
BLER	- For PUCCH format 1: DTX to ACK probability: 1%. NACK to ACK probability: 0.1%. ACK missed detection probability: 1%. - For PUCCH format 3: BLER for Ack/Nack, SR: 1% BLER for CSI: 1%, optional for 10%.
Number of UE transmit chains	1
DMRS configuration	Number of DMRS symbols for PUCCH Format 3: Reported by companies
Repetitions	w/ repetition. The maximum number of repetitions is 8.
PUCCH duration	14 OS
Number of PRBs	1 PRB

Other parameters	Reported by companies

Agreement

For coverage evaluation of PRACH in NR NTN, the following table is assumed.

Parameter	Value
Format	Format 0, Format B4, Format 2
SCS	Reported by companies.
Performance metric	1% missed detection at 0.1% false alarm probability 10% missed detection: reported by companies if this value is used
Number of UE transmit chains	1, 2 (optional)
Other parameters	Reported by companies.

Agreement

For coverage evaluation of PUSCH Msg.3 in NR NTN, the following table is assumed.

Parameter	Value
Frequency hopping	w/ or w/o frequency hopping
Number of UE transmit chains	1, 2 (optional)
Number of DMRS symbol	w/o frequency hopping: 3, w/ frequency hopping: 2 for each hop
Waveform	DFT-s-OFDM
HARQ configuration	Whether/How is adopted is reported by companies.
PUSCH duration	14 OS
Number of PRBs	2
TBS	56 bits
Other parameters	Reported by companies.

Agreement

For coverage evaluation of SSB in NR NTN, the following table is assumed.

Parameter	Value
Number of UE receive chains	2 for 2GHz
Periodicity	20ms
Performance metric	Combination of 4 SSBs in 80ms.

	Note: UE is not assumed to know the SS/PBCH block index
Other parameters	Reported by companies.

Agreement

For coverage evaluation of PDSCH in NR NTN, the following table is assumed.

Parameter	Value
BLER	For low data rate service, w/ HARQ, 10% iBLER; w/o HARQ, 10% iBLER. For VoIP, 2% rBLER.
Waveform	CP-OFDM
Number of UE receive chains	2 for 2GHz
HARQ configuration	Whether/How HARQ is adopted is reported by companies.
DMRS configuration	3 DMRS symbols is used for PDSCH of Msg.2. For 3km/h: Type I, 1 or 2 DMRS symbol, no multiplexing with data. PDSCH mapping Type, the number of DMRS symbols and DMRS position(s) are reported by companies.
PRBs/TBS/MCS for low data rate service	Any value of PRBs, and corresponding MCS index, reported by companies will be considered in the discussion. TBS can be calculated based on e.g. the number of PRBs, target data rate, frame structure and overhead.
PRBs/MCS for VoIP	Any value of PRBs reported by companies will be considered in the discussion. QPSK
PDSCH duration	12 OS
Payload size for PDSCH of Msg.4	1040 bits
Other parameters	Reported by companies.
Other parameters	Reported by companies

Agreement

For coverage evaluation of PDCCH in NR NTN, the following table is assumed.

Parameter	Value
Number of UE receive chains	2 for 2GHz
Aggregation level	16
Payload	40 bits

CORESET size	2 symbols, 48 PRBs
Tx Diversity	Reported by companies
BLER	1% BLER optional for 10% BLER
Number of SSB for broadcast PDCCH of Msg.2	Reported by companies
Other parameters	Reported by companies

9. Appendix-5 (Contact information)

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