**3GPP T****SG-RAN WG2 Meeting #117-e R2-2204033**

**E-Meeting, Feb 21th – Mar 3rd, 2022**

**Agenda item:**  **8.10.3.2.2**

**Source: Intel Corporation**

**Title: Report of email discussion [AT117-e][116][NTN] Measurement gaps (Intel)**

**Document for: Discussion**

# Introduction

This is the report of the following email discussion:

* [AT117-e][116][NTN] Measurement gaps (Intel)

Scope: Discuss measurement gaps for NTN based on e.g. [R2-2202455](file:///C%3A%5CData%5C3GPP%5CExtracts%5CR2-2202455%20Discussion%20on%20NR%20NTN%20measurement%20gaps.docx)

Intended outcome: Summary of the offline discussion

Deadline (for companies' feedback): Wednesday 2022-03-02 0200 UTC

Deadline (for rapporteur's summary in R2-2204033): Thursday 2022-03-03 0400 UTC

# Discussion

## Background information

In NR NTN, the following agreements were made regarding measurement gaps:

1. For Rel-17 NTN, Rel-17 NR operation is enhanced (e.g. the SMTC configuration and UE measurement gap configuration) aiming to address the issues associated with the different/larger propagation delays, and the satellites (considering e.g. their deployment, mobility, height, minimum elevation and prioritizing typical NTN scenarios).
2. Rel-17 NTN will not rely only on network implementation to address the issue explained in agreement 1.

Agreements online:

1. Measurement gaps enhancements should be supported. FFS on the details
2. Measurement gap related aspects for Rel-17 NTN will be addressed in Rel-17 NTN WI. Coordination and avoiding overlap with other WIs and WGs is recommended.
3. RAN2 aims to minimize the number of configurable measurement gaps required for monitoring configured SMTCs in NTN. At least gap length and UE capabilities impact the number of required measurement gaps.

The principle is to coordinate the design in both NR NTN and MGE WIs, therefore the progress made in MGE WI should also be taken into account.

In MGE WI, there are three types of enhancements, i.e., pre-configured measurement gap, multiple concurrent and independent MG patterns, and Network Controlled Small Gap. Among them, the concurrent gap is related to NR NTN as it is supposed to enable more measurement gaps.

The agreements made for concurrent gap are as below:

* RAN2 confirms the following understanding for concurrent gap operation:

1. Concurrent gaps are multiple measurement gaps and each gap pattern could be associated with one or multiple frequency layers.

2. Each frequency layer can be associated with only one of the concurrent gaps.

3. Without considering pre-configured MG, concurrent gaps are always activated if it is setup by the network.

4. No new gap pattern is introduced for concurrent gap, the existing R15/R16 gap pattern could be configured for the concurrent gaps.

* RAN2 to clarify “frequency layer” and limitations as below:

PRS measurement can be associated with one gap pattern, no matter how many frequencies are measured for PRS.

Each measured SSB or LTE frequency is considered as one frequency layer.

Measured CSI-RS resources with the same center frequency is considered as one frequency layer. It is possible to have Multiple MOs including CSI-RS resources with same center frequency.

SSB and CSI-RS measurement in one MO are considered as different frequency layers.

* Introduce multiple gap configuration in IE *MeasGapConfig* (i.e. by configuring multiple *GapConfig*).
* RAN2 don’t supports concurrent gap association to 3G/2G from signalling perspective, but the signalling shall be extendable if this need to be introduced.
* For association between concurrent MG and measured frequencies: Indicate the associated gaps (via “gap ID”) in MO; (for PRS measurement, indicating in the association in MG configuration).

And according to RAN4 LS [1], the feasible numbers of concurrent MGs are shown as follows:

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| **Q3 –** Could concurrent gaps be configured with different gap types (i.e., some gaps are per-UE while some gaps are per-FR)? If so, what is the maximum number of gaps that could be configured simultaneously for each gap type (per-UE /per-FR1/per-FR2)? * RAN4 response:
	+ In Rel-17, UE can be configured with per-UE gap and per-FR gap simultaneously when
		1. UE is capable of per-FR gap and concurrent gaps, and
		2. Per-UE gap is associated with PRS measurements
			- Note: Additional use cases incl. Rel-17 MUSIM and Rel-17 NR NTN WIs are not precluded to be included in future releases.

A list of all supported combinations can be found in below table for reference.

|  |
| --- |
| Combinations of different gap types for per-FR gap capable UE |
| Index | # of simultaneous MG | RAN4 conclusion |
| Per-FR1 | Per-FR2 | Per-UE |
| 0 | 2 | 1 | 0 | Supported |
| 1 | 1 | 2 | 0 | Supported |
| 2 | 0 | 0 | 2 | Supported |
| 3 | 1 | 0 | 1 | Supported when per-UE gap is associated to PRS measurement |
| 4 | 0 | 1 | 1 |
| 5 | 1 | 1 | 1 |
| 6 | 0 | 0 | 1 | Supported |
| 7 | 1 | 1 | 0 | Supported |
| 8 | 1 | 0 | 0 | Supported |
| 9 | 0 | 1 | 0 | Supported |
| 10 | 2 | 0 | 0 | Supported |
| 11 | 0 | 2 | 0 | Supported |

 |

Since in the session of coordination of gaps, the following agreement was made,

* R2 to wait more progress on NTN gap before discussing the co-existence between NTN gap and other gap features.

in NR NTN session, we need to figure out the enhancement to measurement gap for NTN.

## Questionnaire table

According to [2], the following observations are provided:

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| The main idea of concurrent gap is to introduce multiple measurement gaps, but the restriction is that each frequency layer can be associated with only one of the concurrent gaps.**Observation 1: there is restriction in MGE WI that one frequency layer can be associated with only one of the concurrent gaps when introducing multiple measurement gaps.**So RAN4 confirms that one UE can support at most 2 per-UE measurement gaps, or at most 2 measurement gaps for each FR. Since RAN2 agreement was to “minimize the number of configurable measurement gaps required for monitoring configured SMTCs in NTN”, we could follow this assumption that in NR NTN RAN2 doesn’t consider more than 2 per UE or 2 per FR measurement gaps.**Observation 2: RAN4 confirms that one UE can support at most 2 per-UE measurement gaps, or at most 2 measurement gaps for each FR.** |

**Question 1: whether the following proposal can be agreeable:**

**Proposal 1: In NR NTN, RAN2 follows the restriction on the maximum number of gaps that could be configured simultaneously for each gap type (per-UE /per-FR1/per-FR2), i.e., more than 2 simultaneous measurement gaps for each gap type are not considered in R17 NR NTN.**

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| **Company** | **Y or N** | **Additional comments** |
| Huawei, HiSilicon | Y |  |
| CMCC | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| Google | Y |  |
| Qualcomm | Y |  |
| Nokia | Y |  |
| Xiaomi | Y |  |
| MediaTek | Y |  |
| Apple | Y |  |
| OPPO | Y |  |
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**Summary:**

All participant companies agree to the proposal, so this proposal is listed as an “proposal for easy agreements”.

**Proposal 1: In NR NTN, RAN2 follows the restriction on the maximum number of gaps that could be configured simultaneously for each gap type (per-UE /per-FR1/per-FR2) confirmed in MGE WI, i.e., more than 2 simultaneous measurement gaps for each gap type are NOT considered in R17 NR NTN.**

In NR NTN, RAN2 has already agreed on the enhancements to SMTC as below:

1. For Rel-17 NTN, one or more SMTC configuration(s) associated to one frequency can be configured. FFS solution details.

- The SMTC configuration can be associated with a set of cells (e.g., per satellite or any other suitable set per gNB determination).

- The multiple SMTC configurations are enabled by introducing different new offsets in addition to the legacy SMTC configuration.

Agreements:

1. In NW-based solution, the network can configure up to 2 SMTCs in parallel and the UE uses all of them, i.e. there is no switching between or activation/deactivation of configured SMTCs. FFS whether this (UE support for 2 SMTCs) requires a UE capability. A UE can optionally indicate support for 4 SMTCs (in this case the NW can configure up to 4 SMTCs in parallel)

So 2 SMTCs or up to 4 SMTCs can be associated to one frequency, in order to accommodate these SMTCs, concurrent gaps should also be associated to one frequency. Considering at most 2 per-UE measurement gaps, or at most 2 measurement gaps for each FR can be supported, and in baseline RRC CR of MGE WI [3] there is already one indication for the associated gap (i.e., *associatedMeasGapSSB-r17* or *associatedMeasGapCSIRS-r17*), so the second measurement gap should also be configured for the same MO (with same SSB or CSI-RS resource, as a same frequency layer). The corresponding TP is as below, which is based on the baseline RRC of MGE WI [3].

MeasGapConfig ::= SEQUENCE {

 gapFR2 SetupRelease { GapConfig } OPTIONAL, -- Need M

 ...,

 [[

 gapFR1 SetupRelease { GapConfig } OPTIONAL, -- Need M

 gapUE SetupRelease { GapConfig } OPTIONAL -- Need M

 ]],

[[

 gapTwoFR2-r17 SetupRelease { GapConfig } OPTIONAL, -- Need M

 gapTwoFR1-r17 SetupRelease { GapConfig } OPTIONAL, -- Need M

 gapTwoUE-r17 SetupRelease { GapConfig } OPTIONAL -- Need M

 ]]

}

GapConfig ::= SEQUENCE {

 gapOffset INTEGER (0..159),

 mgl ENUMERATED {ms1dot5, ms3, ms3dot5, ms4, ms5dot5, ms6},

 mgrp ENUMERATED {ms20, ms40, ms80, ms160},

 mgta ENUMERATED {ms0, ms0dot25, ms0dot5},

 ...,

 [[

 refServCellIndicator ENUMERATED {pCell, pSCell, mcg-FR2} OPTIONAL -- Cond NEDCorNRDC

 ]],

 [[

 refFR2ServCellAsyncCA-r16 ServCellIndex OPTIONAL, -- Cond AsyncCA

 mgl-r16 ENUMERATED {ms10, ms20} OPTIONAL -- Cond PRS

  ]],

 [[

 measGapId-r17 MeasGapId-r17 OPTIONAL, -- Cond ConcurrentGap

 ]]

}

*Editor Note: It is FFS whether to support use case association that associated a gap to SSB measurement, CSI-RS measurement, or E-UTRAN measurement*

-- TAG-MEASGAPCONFIG-STOP

-- ASN1STOP

*– MeasObjectNR*

The IE *MeasObjectNR* specifies information applicable for SS/PBCH block(s) intra/inter-frequency measurements and/or CSI-RS intra/inter-frequency measurements.

***MeasObjectNR* information element**

-- ASN1START

-- TAG-MEASOBJECTNR-START

MeasObjectNR ::= SEQUENCE {

 ssbFrequency ARFCN-ValueNR OPTIONAL, -- Cond SSBorAssociatedSSB

 ssbSubcarrierSpacing SubcarrierSpacing OPTIONAL, -- Cond SSBorAssociatedSSB

 smtc1 SSB-MTC OPTIONAL, -- Cond SSBorAssociatedSSB

 smtc2 SSB-MTC2 OPTIONAL, -- Cond IntraFreqConnected

 refFreqCSI-RS ARFCN-ValueNR OPTIONAL, -- Cond CSI-RS

 referenceSignalConfig ReferenceSignalConfig,

 absThreshSS-BlocksConsolidation ThresholdNR OPTIONAL, -- Need R

 absThreshCSI-RS-Consolidation ThresholdNR OPTIONAL, -- Need R

 nrofSS-BlocksToAverage INTEGER (2..maxNrofSS-BlocksToAverage) OPTIONAL, -- Need R

 nrofCSI-RS-ResourcesToAverage INTEGER (2..maxNrofCSI-RS-ResourcesToAverage) OPTIONAL, -- Need R

 quantityConfigIndex INTEGER (1..maxNrofQuantityConfig),

 offsetMO Q-OffsetRangeList,

 cellsToRemoveList PCI-List OPTIONAL, -- Need N

 cellsToAddModList CellsToAddModList OPTIONAL, -- Need N

 blackCellsToRemoveList PCI-RangeIndexList OPTIONAL, -- Need N

 blackCellsToAddModList SEQUENCE (SIZE (1..maxNrofPCI-Ranges)) OF PCI-RangeElement OPTIONAL, -- Need N

 whiteCellsToRemoveList PCI-RangeIndexList OPTIONAL, -- Need N

 whiteCellsToAddModList SEQUENCE (SIZE (1..maxNrofPCI-Ranges)) OF PCI-RangeElement OPTIONAL, -- Need N

 ...,

 [[

 freqBandIndicatorNR FreqBandIndicatorNR OPTIONAL, -- Need R

 measCycleSCell ENUMERATED {sf160, sf256, sf320, sf512, sf640, sf1024, sf1280} OPTIONAL -- Need R

 ]],

 [[

 smtc3list-r16 SSB-MTC3List-r16 OPTIONAL, -- Need R

 rmtc-Config-r16 SetupRelease {RMTC-Config-r16} OPTIONAL, -- Need M

 t312-r16 SetupRelease { T312-r16 } OPTIONAL -- Need M

 ]],

 [[

 associatedMeasGapSSB-r17 MeasGapId-r17 OPTIONAL, -- Need R

 associatedMeasGapCSIRS-r17 MeasGapId-r17 OPTIONAL -- Need R

 associatedMeasGapSSB2-r17 MeasGapId-r17 OPTIONAL, -- Need R

 associatedMeasGapCSIRS2-r17 MeasGapId-r17 OPTIONAL -- Need R

 ]]

}

**Question 2: whether the following proposal can be agreeable:**

**Proposal 2:**  **If proposal 1 is agreed, for NR NTN the two measurement gaps should be allowed to be associated with the same frequency layer.**

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| **Company** | **Y or N** | **Additional comments** |
| Huawei, HiSilicon | Y |  |
| CMCC | Y |  |
| vivo | Y |  |
| Samsung | See comment | With observation 1, i.e. one frequency layer (one SSB frequency) can be associated with only one of the concurrent gaps when introducing multiple measurement gaps, the limitation now is that only one measurement gap is associated with the same frequency layer. For CSI-RS resource, CR in MG WI already implemented another associated measurement gap as below. If we want two measurement gaps with the same SSB frequency, do we ignore the limitation that one measurement gap is associated with the same frequency layer or do we need more than 2 measurement gaps in total?MeasObjectNR ::= SEQUENCE { ssbFrequency ARFCN-ValueNR OPTIONAL, -- Cond SSBorAssociatedSSB … omitted [[ associatedMeasGapSSB-r17 MeasGapId-r17 OPTIONAL, -- Need R associatedMeasGapCSIRS-r17 MeasGapId-r17 OPTIONAL -- Need R ]]} |
| Google | Y | Although we agree Proposal 2, we think it is better to clarify that this proposal may contradict the agreement made in the MGE WI. More specifically, this proposal may contradict the agreement “**Each frequency layer can be associated with only one of the concurrent gaps**”. |
| Qualcomm | N | Network can always configure many measurement objects as necessary. We have similar confusion as Samsung. We prefer RAN4 to decide how to use concurrent MGs for NTN use case.It is our understanding that CSI-RS based L3 measurement is not considered in R17 NTN. So there is no need for associatedMeasGapCSIRS2-r17. |
| Nokia | See comment | Agree with others that Proposal2 does not follow the agreement “Each frequency layer can be associated with only one of the concurrent gaps”. Actually, the restriction is from RAN4 (LS R4-2115343), RAN2 may need to ask RAN4 for the feasibility. |
| Xiaomi | Y with comments | Although P2 contradicts with the agreement of concurrent gap, reusing concurrent MGs for NTN may be simpler than introducing NTN specific MGs. How to reuse concurrent MG for NTN can be discussed in Gaps Coordination. If P2 is agreed, RAN2 should send an LS to RAN4 for the feasibility. |
| MediaTek | No | Agree with Samsung, Nokia and Qualcomm that RAN2 cannot decide it by itself. This is more in RAN4 scope of work. |
| Apple | Maybe | We also think that this needs to be decided by RAN4 |
| OPPO | Y |  |
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**Summary:**

The majority view is current P2 does not follow the agreement “Each frequency layer can be associated with only one of the concurrent gaps”. As this is a restriction from RAN4 (LS R4-2115343) as below, if we want to break this restriction, RAN2 needs to ask RAN4 for the feasibility.

|  |
| --- |
| * Each frequency layer can be associated with only one MG (leave it for RAN2 on how to implement the association)
	+ SSB, CSI-RS and PRS are treated as different frequency layers

One MG can be associated with multiple frequency layers, while one frequency layers can only be associated to a single MG. |

**Proposal 2: RAN2 to discuss whether** **two measurement gaps could be associated with the same frequency layer:**

**Option 1: Yes, and send a LS to RAN4 for confirmation.**

**Option 2: No, RAN2 sticks to the restriction from RAN4 (LS R4-2115343).**

**Option 3: leave this discussion to Gaps Coordination in main session.**

If P2 can be agreed, it means for one frequency layer, e.g. one MO with SSB resource, at most 2 measurement gaps can be used in parallel. Meanwhile the SMTC number could be 2 or 4. Usually the length of measurement gap is a bit longer than that of SMTC. The configurations of SMTC length and gap length are shown as below:

SSB-MTC ::= SEQUENCE {

 periodicityAndOffset CHOICE {

 sf5 INTEGER (0..4),

 sf10 INTEGER (0..9),

 sf20 INTEGER (0..19),

 sf40 INTEGER (0..39),

 sf80 INTEGER (0..79),

 sf160 INTEGER (0..159)

 },

 duration ENUMERATED { sf1, sf2, sf3, sf4, sf5 }

}

GapConfig ::= SEQUENCE {

 gapOffset INTEGER (0..159),

 mgl ENUMERATED {ms1dot5, ms3, ms3dot5, ms4, ms5dot5, ms6},

 mgrp ENUMERATED {ms20, ms40, ms80, ms160},

 mgta ENUMERATED {ms0, ms0dot25, ms0dot5},

 ...,

So if we consider the periodicities of SMTC and measurement gap are the same, two measurement gaps can accommodate 2 SMTCs, but it’s not possible to cover 4 SMTCs based on current configuration. Even though RAN2 has confirmed that SMTCs can overlap, it’s still not clear how to address this case.

Considering UE may still benefit from 4 SMTCs in non-gap-assisted scenarios, it could be left up to network implementation to configure appropriate measurement gap and SMTC in gap assisted measurement scenarios, i.e., the network makes sure the measurement gaps can cover all SMTCs configured for one frequency layer.

**Question 3: Whether the following proposal is agreeable:**

**Proposal 3: it’s up to network implementation to guarantee that the measurement gaps can cover all SMTCs configured for one frequency layer in gap-assisted scenarios.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y or N** | **Additional comments** |
| Huawei, HiSilicon | Y |  |
| CMCC | Y |  |
| vivo | Y |  |
| Samsung | Y |  |
| Google | See comment | Gap length may need to be extended in NTN, in order to make it possible to use two gaps to accommodate four non-overlapped SMTCs.  |
| Qualcomm | Y | There is already MG length of 10ms which can be used in NTN. |
| Nokia | Y with comment | Agree with Google the MGL may need to be extended and it is not so straightforward for the NW to ensure gaps cover all SMTCs. But we are fine to keep the existing values for early NTN deployment and also think 2 SMTCs per carrier could be enough to begin with.  |
| Xiaomi | Y | Whether to extend the MGL in NTN can be decided by RAN4. |
| MediaTek | Yes |  |
| Apple | Y |  |
| OPPO | Y |  |
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**Summary:**

Some companies think MG length needs to be extended in NTN to accommodate up to four SMTCs, but rapporteur also agrees with Xiaomi that whether to extend the MGL in NTN should be decided by RAN4. The clear majority view is to agree that it’s up to network implementation to guarantee that the measurement gaps can cover all SMTCs configured for one frequency layer in gap-assisted scenarios. It can be considered as “proposals for easy agreements”.

**Proposal 3: it’s up to network implementation to guarantee that the measurement gaps can cover all SMTCs configured for one frequency layer in gap-assisted scenarios.**

# Conclusion

Based on this offline discussion on measurement gaps, the following proposals are made:

** List of proposals for easy agreement:**

**Proposal 1: In NR NTN, RAN2 follows the restriction on the maximum number of gaps that could be configured simultaneously for each gap type (per-UE /per-FR1/per-FR2) confirmed in MGE WI, i.e., more than 2 simultaneous measurement gaps for each gap type are NOT considered in R17 NR NTN.**

**Proposal 3: it’s up to network implementation to guarantee that the measurement gaps can cover all SMTCs configured for one frequency layer in gap-assisted scenarios.**

** List of proposals that require online discussions:**

**Proposal 2: RAN2 to discuss whether** **two measurement gaps could be associated with the same frequency layer:**

**Option 1: Yes, and send a LS to RAN4 for confirmation.**

**Option 2: No, RAN2 sticks to the restriction from RAN4 (LS R4-2115343).**

**Option 3: leave this discussion to Gaps Coordination in main session.**

# References

1. R2-2202158 Further reply LS on R17 NR MG enhancements – Concurrent MG RAN4
2. R2-2202455 Discussion on NR NTN measurement gaps Intel Corporation
3. R2-2201903 RRC signaling for measurement gap enhancement MediaTek Inc.