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

**Electronic Meeting, February 21 – March 3, 2022**

**Agenda item:** 10.13.5.1, 10.13.5.3, 10.13.5.5

**Source:** Qualcomm Incorporated

**Title:** WF on NR NTN RRM requirements

**Document for:** Approval

# Introduction

*This document is to capture the WF on RRM mobility and measurement requirements for NR NTN. The scope of WF includes the following agenda items:*

* *10.13.5.1 - General*
* *10.13.5.3 - Mobility requirements*
* *10.13.5.5 - Measurement procedure requirements*

# Topic #1: General requirements

## Issue 1-5: Cell Service Time

**Issue 1-5-1-A: Measurement based on Cell Service Time (When to start the detection, measurement and evaluation on neighbour cells)**

**Agreement:**

* In NTN idle/inactive mode, if the serving cell service time is broadcasted and applicable,
	+ the UE shall start the detection, measurement and evaluation on neighbour cells at the time when the legacy S/R criteria are met, e.g. serving cell RSRP is worse than threshold.

**Issue 1-5-1-B: Measurement based on Cell Service Time (Requirement applicability)**

**Agreement:**

* Time-based conditions:
	+ The NTN cell reselection requirement does not apply when the time span from the last slot of SI transmission within SI modification period where the broadcasting of ‘serving cell stop time’ is started to the first slot when the cell is scheduled to stop serving the area according to the broadcasted information is less than Ttrigger. Ttrigger is
		- max(Tdetect,NR\_Intra, Nlayer\*[60s]), when serving cell is above the search threshold
		- max(Tdetect,NR\_Intra, Kcarrier\* Tdetect,NR\_Inter), when serving cell is below the search threshold
		- Kcarrier is the number of NR inter-frequency carriers indicated by the serving cell
		- Nlayers is the total number of higher priority NR carrier frequencies broadcasted in system information
		- Tdetect,NR\_Intra is HST intra-frequency cell detection delay in IDLE/Inactive mode defined Table 4.2.2.3-2
		- Tdetect,NR\_Inter is HST intra-frequency cell detection delay in IDLE/Inactive mode defined Table 4.2.2.3-2
* Location-based conditions:
	+ If Srxlev ≤ SnonIntraSearchP or Squal ≤ SnonIntraSearchQ, or the distance between UE and serving cell reference location is larger than [threshold + Dmargin] if the [threshold] is configured and UE has location information, where Dmargin = [50]m
		- the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection

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## Issue 1-6: Neighbour/Target Cell/Satellite Information Acquisition

**Issue 1-6-1: If valid neighbour/target cell’s timing information in terms of validity or accuracy is not provided to UE,**

**Agreement:**

* Define “availability of valid target satellite information as side condition”
	+ Parameters listed in R2-2201884 are defined as the required target satellite information for measurement and mobility.
		- For measurement
			* Ephemeris
			* Epoch time
			* SMTCs
			* DL polarization information
			* Serving cell stop time and reference location for IDLE mode measurement trigger in NGSO fixed cell, if applicable
			* Under RAN1 discussion:
				+ Feeder link delay (i.e., common TA and K\_MAC) of the neighbor cell should also be provided to UE for neighbor cell SMTC adjustment
				+ separate validity timers
		- For mobility
			* Target cell Ephemeris information
			* Epoch time of the ephemeris
			* Common TA
			* Validity timer information for target cell mobility
			* DL and UL Polarization information
			* K\_offset
			* Kmac (to determine UE-gNB RTT and perform RACH to target)
* If the side condition is not met,
	+ Requirements are not applied, i.e. extra delay won’t be explicitly defined
	+ Note: UE is allowed not to perform RRM measurement [and reporting] if the side condition is not met before acquiring new ephemeris information

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## Issue 1-7: RRM Spec Documentation

**Issue 1-7-1: A spec structure of NTN UE RRM requirements**

**Agreement:**

* Requirements for NTN are defined in separate sections from legacy ones and use suffix ‘C’
* NTN Detailed terminologies, e.g. NTE and satellite access, are subject to an outcome of feature list from other working groups

## Issue 1-8: Signalling characteristics

**Issue 1-8-1-A: Requirements related to Signalling Characteristics (HO between FR1 and FR2)**

**Agreement:**

* The following NTN UE mobility across different FRs is not supported
	+ NR FR2 – NR FR1 HO
	+ NR FR1 – NR FR2 HO
	+ NR FR2 – NR FR2 HO
* (Note) NTN UE mobility within FR1 between NTN and TN is not precluded

**Issue 1-8-1-B: Requirements related to Signalling Characteristics (RLM and BFR)**

**Agreement:**

* Enhancements for RLM and Link Recovery requirements are not considered in Rel-17, i.e. the same as legacy requirements
* Add scaling factor K on
	+ TEvaluate\_out\_SSB and TEvaluate\_in\_SSB in Table 8.1.2.2-1
	+ TEvaluate\_out\_CSI-RS and TEvaluate\_in\_CSI-RS in Table 8.1.3.2-1
	+ TEvaluate\_BFD\_SSB in Table 8.5.2.2-1
	+ TEvaluate\_BFD\_CSI-RS in Table 8.5.3.2-1
	+ Example for Table 8.1.2.2-1. Value ‘K’ will be determined during performance requirement phase.

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| Table 8.1.2.2-1: Evaluation period TEvaluate\_out\_SSB and TEvaluate\_in\_SSB for FR1

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| Configuration | TEvaluate\_out\_SSB (ms)  | TEvaluate\_in\_SSB (ms)  |
| no DRX | Max(200, Ceil(10 × P) × [K]× TSSB) | Max(100, Ceil(5 × P) × [K] × TSSB) |
| DRX cycle≤320ms | Max(200, Ceil(15 × P) × [K] ×Max(TDRX,TSSB)) | Max(100, Ceil(7.5 × P) × [K] × Max(TDRX,TSSB)) |
| DRX cycle>320ms | Ceil(10 × P) × [K] × TDRX | Ceil(5 × P) × [K] × TDRX |
| NOTE: TSSB is the periodicity of the SSB configured for RLM. TDRX is the DRX cycle length. |

Where, K= [1, 2] for GEO an LEO Earth-fixed satellite; K= [0.5, 1] for LEO Earth-moving satellite. |

* + (Note) Whether/how to deal with parallel measurements between L1 and L3 from different satellites is separately addressed
	+ (Note) A value of K will be determined in performance requirement development phase, and K=1 means no enhancement/relaxation.

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# Topic #2: Mobility requirements

## Issue 2-1: Cell selection and reselection

**Issue 2-1-3: Cell Selection/Reselection delay requirements**

**Agreement:**

* The enhanced cell reselection delay requirements (Tdetect,NR\_Intra, Tmeasure,NR\_Intra and Tevaluate,NR\_Intra) defined for FR1 HST can be applied to NTN scenario.
* The above is subject to NW indication and UE capability.

**Issue 2-1-4: Higher priority search**

**Agreement:**

* Higher priority search delay requirements for GEO
	+ The current higher priority search delay requirements will apply for UE Idle/Inactive mode for GEO scenarios, i.e., K=60 and M\_layers = N\_layers
* Higher priority search delay requirements for LEO
	+ M\_layers = N\_layers
	+ K=60
* RRM requirements are defined based on single NTN deployment scenario, i.e. serving and neighbour satellites are of same type (GEO or LEO)

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**Issue 2-1-5-A: Maximum interruption in paging reception**

**Agreement:**

* The maximum interruption in paging reception for NTN cell reselection shall not exceed
	+ If the target cell belongs to the same satellite as the current one
		- If the target cell is known, TSI-NR + 2\*Ttarget\_cell\_SMTC\_period
		- If the target cell is unknown, TSI-NR + 5\* Ttarget\_cell\_SMTC\_peri
	+ If the target cell belongs to a different satellite than the current one and the target cell’s satellite is GEO
		- If the target cell is known, TSI-NR + 2\*Ttarget\_cell\_SMTC\_period
		- If the target cell is unknown, TSI-NR + 5\* Ttarget\_cell\_SMTC\_period
	+ If the target cell belongs to a different satellite than the current one and the target cell’s satellite is non-GEO
		- TSI-NR + 5\* Ttarget\_cell\_SMTC\_period

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**Issue 2-1-5-B: Measurement with paging reception**

**Agreement:**

* Scaling factor M1 and M2 on measurement relaxation with paging shall be updated in NTN.
	+ M1=[2.5] if SMTC periodicity (TSMTC) > 20 ms and DRX cycle ≤ 0.64 second, for serving cell measurement, upon more than one SMTC.
	+ M2= [2] if SMTC periodicity (TSMTC) > 20 ms and DRX cycle ≤ [0.64] second, for intra-frequency [and inter-frequency cell measurement], upon more than one SMTC.

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**Issue 2-1-6: UE initiated measurement for cell (re)selection**

**Agreement:**

* UE initiates the measurement for cell-reselection in IDLE/Inactive mode if the distance between UE and serving cell reference location is longer than a ‘network-configured threshold + Dmargin’, where Dmargin is [X] meters.
* (Note) A value of X will be determined in performance requirement development phase.

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## Issue 2-2 HO and CHO

**Issue 2-2-1: Timeline for NTN CHO**

**Agreement:**

* DCHO\_NTN = TRRC + Tevent\_DU + Tmeasure + Tinterrupt + TCHO\_execution, where
	+ TRRC is the RRC procedure delay.
	+ UE starts RRM measurement even before T1 or Distance condition is met
		- Tevent\_DU:
			* the delay uncertainty which is the time from when the UE successfully decodes a conditional handover command until a measurement condition exists at the measurement reference point.
		- Tmeasure:
			* For Time-based CHO (in combination with the existing R16 CHO measurement)
				+ If T1 is earlier than the timing when UE identified target cell met RRM condition, Tmeasure is time from the end of Tevent\_DU until the timing when UE identified target cell met RRM condition.
				+ Otherwise, Tmeasure is time from the end of Tevent\_DU until T1.
			* For Location-based CHO (in combination with the existing R16 CHO measurement)
				+ If distance condition is met earlier than the timing when UE identified target cell met RRM condition, Tmeasure is time from the end of Tevent\_DU until the timing when UE identified target cell met RRM condition.
				+ Otherwise, Tmeasure is time from the end of Tevent\_DU until distance condition is met.
	+ TCHO\_execution:
		- the UE execution preparation time for conditional handover. (same as legacy TN TCHO\_execution)
	+ Tinterrupt is the time between when the UE starts to execute the conditional handover to the target cell and the time the UE starts transmission of the new PRACH.
* Requirement/Test applicability and Others
	+ For Time-based CHO (in combination with the existing R16 CHO measurement)
		- If T2 is earlier than the end the Tmeasure, no CHO requirement is applied.
	+ For Location-based CHO (in combination with the existing R16 CHO measurement)
		- CHO shall only be carried out when “condEvent D1” is met and requirements can be reused by adding “condEvent D1” to the legacy condition.
	+ General
		- Remove the requirements for the case “undetectable cell becomes detectable again” for NTN CHO.

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**Issue 2-2-3: Measurement Prioritization during CHO**

**Agreement:**

* When UE is configured with C (location and RRM) or D (time and RRM) for CHO, RRM requirements are defined assuming UE prioritize measurements of the SMTC window and frequency layer which the target cell belongs to, if the condition for location or time is met

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# Topic #3: Measurement procedure requirements

## Issue 3-1: Multiple SMTCs and Measurement Gap

**Issue 3-1-3: Capability on the number of Measurement Carriers/Cells/SSBs**

**Agreement:**

* Define the following common measurement capability requirements for all scenarios:
	+ the number of NTN carriers UE needs to monitor is 3 including serving CC
	+ the number of NTN and TN carriers UE needs to monitor is 7 including serving CC
		- Requirements do not apply to VSAT UE
	+ the number of SSB beams UE needs to monitor per carrier is 8
* For LEO,
	+ the number of target satellites UE needs to monitor per carrier is 2 including serving LEO satellite
	+ introduce UE capability for the number of target satellites the UE can monitor per carrier including serving LEO satellite, which can be up to [X].
	+ (note) A value of X will be de determined in performance requirement development phase. Candidate values are 4 and 6.

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**Issue 3-1-4A: Measurement with multiple SMTCs (Item-1: Scheduling restriction)**

**Agreement:**

* For measurements of cells belonging to the same satellite as the serving cell:
	+ No additional scheduling restrictions will be defined
	+ Note: existing scheduling restrictions requirements may apply
* For measurements of cells belonging to different satellite as the serving cell and performed outside the MG:
	+ When either serving cell or neighbour cell belongs to NGSO, whether a UE can perform measurements on cells belonging to different satellite as the serving cell in parallel with normal operation (i.e. data/control transmission and/or reception, and L1 measurements) of serving cell without scheduling restrictions is up to UE capability.
		- L1 measurements include RLM/CBD/BFD/L1-RSRP
	+ The capability applies for intra-frequency and inter-frequency measurements
	+ The capability applies for inter-frequency if UE supports *interFrequencyMeas-NoGap-r16* and the flag *interFrequencyConfig-NoGap-r16* is configured by the Network
	+ For UEs not able to perform measurements in parallel with normal operation of serving cell scheduling restrictions shall apply.

**\_\_\_Issue 3-1-4B: Measurement with multiple SMTCs (Item-2: Scaling factor)**

***Tentative agreement:***

* When UE is configured with multiple SMTCs on the same measurement carrier (not more than UE capability),
	+ Option 1a: MTK, Huawei, Apple, Xiaomi
		- If SMTCs do not overlap with each other, a scaling factor of measurement period is
			* Not needed, if only one LEO satellite is required to be measured within SMTC
			* Proportional to the number of LEO satellite, if multiple LEO satellites are required to be measured within SMTC
		- If SMTCs partially overlap with each other, a scaling factor of measurement period is
			* Proportional to the number of overlapping SMTCs, if only one LEO satellite is required to be measured within SMTC
			* Proportional to (the number of overlapping SMTCs) x (the number of LEO satellite), if multiple LEO satellites are required to be measured within SMTC.
	+ Option 1b: Ericsson
		- Scaling factor of measurement period is K1\*K2
			* K1=1, If SMTCs do not overlap with each other, or
			* K1: proportional to the number of overlapping SMTCs, If SMTCs partially overlap with each other
			* K2= 1, if the number of satellites(at least one LEO) required to be measured is less than or equal to number of LEO satellites UE is capable to measure in one SMTC, or
			* K2: proportional to ‘number of satellites(at least one LEO) required to be measured/ number of LEO satellites UE is capable to measure in one SMTC’, if number of satellites(at least one LEO) required to be measured is greater than number of LEO satellites UE is capable to measure in one SMTC.
	+ Introduce the following scheduling restriction cap as applicability condition for the requirements
		- Measurement requirements is not applicable when overall overhead ratio due to scheduling restriction caused by all configured SMTCs (e.g. scheduling restriction overhead of all SMTCs in one periodicity / SMTC periodicity) is larger than [X]%
		- (note) A value of X will be determined in performance requirement development phase. One of candidate values is 75.

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**\_\_\_Issue 3-1-4C: Measurement with multiple SMTCs (Item-3: SSBs fully or partially contained SMTC)**

***Tentative agreement:***

* For UE in RRC Connected mode:
	+ No requirements are expected for SSB outside of SMTC
* For UE in RRC Idle/Inactive mode:
	+ Option 1: LGE, Huawei, Xiaomi
		- No requirements are expected for SSB outside of SMTC
	+ Option 2: Qualcomm, Nokia, Ericsson
		- If UE is provided with required information to figure out whether and how SMTC(s) is shifting in the time domain, measurement requirements for SSB outside of the corresponding SMTC can be applied, subject to UE capability. If any of the following information is not made available to UE, no requirements are applied.
			* Ephemeris
			* Epoch time
			* Feeder link delay
			* Validity timers

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**\_\_\_Issue 3-1-4D: Measurement with multiple SMTCs (Item-4: Requirements when the number of configured SMTCs per Frequency layer is beyond UE capability)**

***Tentative agreement:***

* For RRC Connected mode:
	+ UE is not expected to be configured with more SMTCs than its capability.
* For RRC Idle/Inactive mode:
	+ UE can be configured with more SMTCs than its capability.
	+ Option 1: Qualcomm, Nokia, Ericsson
		- UE may only measure SMTCs which number is same to its capability. The choice can be UE’s implementation [FFS or pre-defined].
	+ Option 2: Ericsson
		- UE selects the SMTCs based on the RSRP measurements
	+ Option 3: Huawei, Apple, CATT, Nokia
		- UE may measure all configured SMTCs through extra measurement delay which is represented by a scaling factor = ‘the number of SMTCs configured by network’/’the number of SMTCs supported by UE’

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**Issue 3-1-4E: Measurement with multiple SMTCs (Item-5: Fully or partially colliding SMTCs)**

**Agreement:**

* A condition of SMTC collision
	+ Two SMTC occasions in parallel are defined as colliding (overlapping) if the 2 SMTCs are partially overlapping in time domain or the minimum distance is less than [4]ms.
* UE measurements in overlapped SMTCs
	+ UE performs measurements in overlapped SMTCs
		- Define requirements assuming UE measures in only one SMTC when SMTCs on the same carrier overlap, i.e. measurement period is scaled if two SMTCs on the same carrier overlap.

**\_\_\_Issue 3-1-6: Measurement Gap**

**Agreements (from first round GTW)**

* UE capability for the maximum number of supported MGs
	+ NTN UE can support either one MG or two MGs subject to UE capability
	+ Note: the decision can be revisited in case it is identified that the agreement contradicts to RAN2 design

***Tentative agreement:***

* For UE supporting one MG
	+ Legacy MG will be used without any change
* For UE supporting two MGs
	+ Except the following aspects, outcome of on R17 concurrent MG item will be directly adopted
		- Modification of MG Colliding/Proximity condition to [FFS]ms
		- Exclusion of enhancement related to positioning application
		- Exclusion of enhancement related to FR2
		- [FFS] Limitation on association between MG and frequency layer
	+ Whether “ Scaling factor due to overlapping MG’” aspects will be introduced
		- Option 1: Ericson
			* Neither “sharing rule” or “priority rule” isn’t precluded
		- Option 2: MTK, LGE, Huawei, Apple, Xiaomi, CATT
			* Yes, it replaces “priority rule”
		- Option 3: Huawei, Apple, Qualcomm
			* No, “priority rule” will be reused

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## Issue 3-2: Measurement relaxation

**Issue 3-2-1: Measurement Relaxation**

**Agreement:**

* Reuse current TN measurement relaxation for NTN UE in GEO

## Issue 3-3: Other aspects for Measurement procedure requirement

**Issue 3-3-1: Measurement requirements and serving cell SIB reading time**

**Agreement:**

* If essential information for NTN neighbour cell measurement is not provided,
	+ No requirement is applied

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# Topic #4: UE Capability

## Issue 4-1: NTN UE Capability

**Issue 4-1-0: View collection for NTN UE Capability**

**Agreement:**

* The following NTN UE capabilities will be defined as UE optional capability, and the details are subject to be further discussion in the next RAN4 meeting:
	+ Parallel measurement and normal operation
	+ Parallel measurement of LEO in one SMTC
	+ Support enhanced (e.g. TN HST) Idle/Inactive mode cell reselection requirements for LEO
	+ Perform measurements on more than one neighbor cells belonging to different satellites in parallel without scaling.
	+ Measurement for more than 2 LEO satellites per carrier ([ or 6])
	+ Support performing measurements on different numbers of target cells within multiple SMTCs on a single carrier
	+ Support 2 parallel measurement gaps
	+ Support performing measurements on cells belonging to different satellite as the serving cell at the same time with normal operations in serving cell

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**Issue 4-1-1: Capability/Feature Details**

**Agreement:**

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| Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| X-Y-1 | Parallel measurements on multiple SMTC-s for a single frequency carrier | Support of measurements ~~without scaling~~ on target cells belonging to maximum of 2 or 4 different [NGSO satellites] |  | yes | no | UE does not support NTN RRM measurements with multiple SMTC configurations | [Per UE] | FDD only | FR1 only | NA | RAN2 recommendation is that UE is mandatory to support 2 and optional to support 4 | Optional with capability signalling |
| X-Y-2 | Parallel measurements on cells belonging to different [NGSO satellite] as the serving cell without scheduling restrictions | Support of measurements on cells belonging to different satellite as the serving cell in parallel with normal operation (i.e. data/control transmission and/or reception, [and L1 measurements]) of serving cell without scheduling restrictions |  | yes | no | UE does not support measurements on cells belonging to different [NGSO satellite] as the serving cell in parallel with normal operation | [Per UE] | FDD only | FR1 only | NA | For UEs not able to perform measurements in parallel with normal operation of serving cell scheduling restrictions shall apply | Optional with capability signalling |
| X-Y-3 | Parallel measurements with multiple measurement gaps | Support of maximum number of supported measurement gaps |  | yes | no | UE does not support more than one measurement gap for NTN RRM measurements | Per UE | FDD only | FR1 only | NA | Candidate values are 1 or 2.The decision can be revisited in case it is identified that the agreement contradicts to RAN2 design | Optional with capability signalling |
| X-Y-4 | Enhanced RRM requirements for measurement in Idle and Inactive mode  | Support of enhanced RRM requirements for measurement in Idle and Inactive mode as specified in TS 38.133 |  | no | no | UE does not support of enhanced RRM requirements for measurement in Idle and Inactive mode | Per UE | FDD only | FR1 only | NA |  | Optional without capability signalling |

# References

[1] R4-2207061, “Email discussion summary: [102-e][220] NR\_NTN\_solutions\_RRM\_1,” 3GPP TSG-RAN WG4 Meeting #102- es