**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)**

***Tentative agreement:***

* Time-based conditions:
  + Option 1-A:
    - The UE shall be able to evaluate whether a newly detectable intra-frequency cell meets the reselection criteria defined in TS38.304 [1] within Tdetect,NR\_Intra when that Treselection= 0 before serving cell is going to stop serving the area, if applicable’
  + Option 1-B:
    - 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
      * Option 1-B-1:
        + max(Tdetect,NR\_Intra, Kcarrier\*max(Tdetect,NR\_Inter,i)), when serving cell is above the search threshold
        + max(Tdetect,NR\_Intra, Nlayer\*[60s]), 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
      * Option 1-B-2:
        + max(Tdetect,NR\_Intra, K\*Tdetect,NR\_Inter)
        + 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
        + K is the inter-frequency carrier number based on NTN UE measurement capability in IDLE/Inactive mode
* Location-based conditions:
  + If Srxlev ≤ SnonIntraSearchP or Squal ≤ SnonIntraSearchQ, or the distance between UE and serving cell reference location is larger than [threshold] if the [threshold] is configured and UE has location information,
    - Option 2-A: the UE shall be able to evaluate whether a newly detectable intra-frequency cell meets the reselection criteria defined in TS38.304 [1] within Tdetect,NR\_Intra when that Treselection= 0 .
    - Option 2-B: the UE shall search for and measure inter-frequency layers of higher, equal or lower priority in preparation for possible reselection

***Further comments:***

* Based on comments received in the second round, Options are modified.
* If you have any concern, please be concise and provide your proposal in a form that can be captured in the set of agreements as is.
* Please provide an exact definition of this.

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| **Company** | **Comments** |
| LGE | For cell stop time based measurement trigger condition, following condition should be captured.   |  | | --- | | UE shall be able to detect, measure, and evaluate intra-frequency measurement before the serving cell stops covering the current area, regardless of if Srxlev and Squal condition are met |   As we commented in 1st round, this condition is already agreed in RAN2 #116e.  For location-based conditions, we support option 2-B. Also, we think the option 2-B is similar to the proposal in issue 2-1-6 except for the value of GNSS margin.  Also, following location based measurement trigger condition is should be captured as agreed in RAN2 #116-e-bis.   |  | | --- | | UE may choose not to perform neighbour cell measurements of “NR intra-freq or inter-freq with equal or lower priority, or inter-RAT freq with lower priority”, if (the distance between UE and serving cell reference location is shorter than a threshold) and (legacy Srxlev/Squal condition is met, i.e., serving cell’s Srxlev/Squal is better than a threshold). | |
| Huawei | For time based condition, support 1-A for simplicity. We can also support 1-B-1 if exact applicability conditions are to be defined. On this, this is our proposal based on the consideration that differnet carriers may have different SMTC, but you can change max(Tdetect,NR\_Inter,i) to Tdetect,NR\_Inter since the measurement delay would be determined by DRX cycle which is same for all carriers.  For location based condition, support 2-B. This condition is similar as “Srxlev ≤ SnonIntraSearchP or Squal ≤ SnonIntraSearchQ”, so we should use same wording as in legacy requirements. |
| Apple | For time-based condition, we support option 1-B-2. Option 1-A is simple, but we still think that: RAN2 only defined that UE shall start measurement before ‘serving cell stop time’ but whether or not UE could complete measurement/evaluation of neighbour cell before ‘serving cell stop time’ is up to how much time left to UE before the ‘serving cell stop time’. Thus, the applicability for requirement is needed, and ‘if applicable’ in option 1-A is not very clear to us.  For location based condition, we are fine with option 2-B and we propose to change [threshold] to [threshold + GNSS margin] as discussed in issue 2-1-6. |
| LGE2 | Additional comments based on our first one. Clear description for measurement triggering condition on top of these discussion should be needed, so to capture the condition in the specification, we propose as following   * + Following condition for intra-frequency measurement should be captured in RRM specification.     - Measurement of intra-frequency NTN cell       * When cell stop time is only broadcasted and applicable,         + UE shall be able to detect, measure, and evaluate intra-frequency measurement before the serving cell stops covering the current area, regardless of if Srxlev and Squal condition are met.       * When serving cell reference location is only broadcasted and applicable,         + UE shall start intra-frequency measurement if the distance between UE and serving cell reference location is longer than a [threshold]. (The threshold is one of the location-related parameters broadcasted by network)         + UE may choose not to perform intra-frequency measurement if the distance between UE and serving cell reference location is shorter than a [threshold] and Srxlev/Squal condition is met.       * When both cell stop time and serving cell reference location are broadcasted and applicable,         + UE shall be able to detect, measure, and evaluate intra-frequency measurement before the serving cell stops covering the current area, regardless of if the distance between UE and serving cell reference location or Srxlev and Squal condition are met.   + Following condition for inter-frequency / inter-RAT frequency measurement should be captured in RRM specification.     - Measurement of inter-frequency / inter-RAT frequency NTN cell       * When cell stop time is only broadcasted and applicable,         + If Srxlev > SnonOntraSearchP and Squal > SnonIntraSearchQ then UE shall search for and measure inter-frequency / inter-RAT frequency layer of higher priority and UE shall be able to detect, measure, and evaluate equal or lower priority inter-frequency / inter-RAT frequency layer before the serving cell stops covering the current area.         + If Srxlev ≤ SnonOntraSearchP and Squal ≤ SnonIntraSearchQ then UE shall search for and measure inter-frequency / inter-RAT frequency layer of higher, equal, or lower priority in preparation for possible reselection.       * When serving cell reference location is only broadcasted and applicable,         + If Srxlev > SnonOntraSearchP and Squal > SnonIntraSearchQ and the distance between UE and serving cell reference location is shorter than a [threshold], then UE shall search for and measure inter-frequency / inter-RAT frequency layer of higher priority.         + If Srxlev ≤ SnonOntraSearchP and Squal ≤ SnonIntraSearchQ or the distance between UE and serving cell reference location is longer than a [threshold], then UE shall search for and measure inter-frequency / inter-RAT frequency layer of higher, equal, or lower priority in preparation for possible reselection.       * When both cell stop time and serving cell reference location are broadcasted and applicable,         + FFS (need to wait RAN2 conclusion) |
| Xiaomi | For time-based condition, we think option 1-A and 1-B does not contradict each other, option 1-A is to clarify that UE shall start the measurement before “serving cell stop time”, and option 1-B is to clarify whether the requirement is applied when the time span is less than Ttrigger. Regarding Ttrigger, we prefer to use option 1-B-1 as baseline and suggest to merge option 1-B-1 and 1-B-2 as follows:   * + - * + max(Tdetect,NR\_Intra, Kcarrier\*max(Tdetect,NR\_Inter,i)), when serving cell is above the search threshold         + max(Tdetect,NR\_Intra, Nlayer\*[60s]), 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   For location based condition, we are fine with option 2-B. |

## 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,**

***Tentative 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,
  + Option 1:
    - Requirements are not applied, i.e. extra delay won’t be explicitly defined
  + Option 2:
    - For mobility requirements,
      * an additional latency for necessary information reading, e.g. **NTN specific system information from a target cell**, is explicitly added if part of necessary information is either not available or invalid during cell (re)selection and (conditional) handover.
    - For measurement requirements,
      * when configured **multiple SMTCs** on the same frequency **are mutually exclusive** in the time domain,
        + measurement period is scaled up proportionally to the number of SMTCs.
      * when configured multiple SMTCs on the same frequency are **not** mutually exclusive in the time domain,
        + the requirements are applicable only when UE is provided with information of the target measurement cells that have the colliding SMTCs.

***Further comments:***

* Based on offline comments, Option 2 is added back. Please also consider whether we can introduce UE capability, which may be much safer spec design compared to ‘no requirement at all’.

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| **Company** | **Comments** |
| LGE | We support option 1. But we want to add note as follows:   * + Option 1:     - Requirements are not applied, i.e. extra delay won’t be explicitly defined     - Note: UE stops RRM measurement and reporting if the side condition is not met before acquiring new ephemeris information. |
| Ericsson | We’re positive to introduce UE capability. |
| Huawei | We support option 1.  On the note suggested by LGE, we suggest to update it to “UE is allowed not to perform RRM measurement and reporting …”.  Based on RAN2 feedback, we do not see strong need to define requirements as in option 2. For mobility we can simply state that the HO delay can be longer. For measurement, we do not see why this is related to multiple SMTC. |
| Apple | We support option 1 and fine with HW’s suggestion on the wording in LGE’s note. Since in RAN2 reply LS, it was clearly answered that,  RAN2 answer: RAN2 assumes all the information needed for measurement and handover would be provided to the UE by the network. If any of the information is not available or is not valid, then the UE would have to acquire the system information of the target or neighbor cell which is not desirable from handover interruption time point of view.  We shall not consider the scenario that information is not provided. |
| Xiaomi | Support option 1, and fine with HW and LGE comments on the note. According to RAN2 reply, the case when information used for measurement or handover is not provided or not valid is not desirable from handover interruption time point of view, so we do not need to define the requirement for this case. |

## 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)**

***Tentative 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
  + FFS#1: TEvaluate\_out\_CSI-RS and TEvaluate\_in\_CSI-RS in Table 8.1.3.2-1
  + FFS#2: TEvaluate\_BFD\_SSB in Table 8.5.2.2-1
  + FFS#3: 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   |  |  |  | | --- | --- | --- | | 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= [2] for GEO an LEO Earth-fixed satellite; K= [1] for LEO Earth-moving satellite. |

* + (Note) Whether/how to deal with parallel measurements between L1 and L3 from different satellites is separately addressed

***Further comments:***

* If you have any concern, please be concise and provide your proposal in a form that can be captured in the set of agreements as is.
* Based on Ericsson comment received in the second round, 2nd bullet is reverted back to being part of candidate agreements. And I took the liberty of adding FFS#1,2,3 to clarify if the scaling factor is only for SSB based RLM or applicable to CSI-RS based RLM and BFD too. If any concern on bullets with FFS is not received, “FFS#x” will be removed in the final version of WF.

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| **Company** | **Comments** |
| MTK | Our understanding is the scaling factor is also applicable to SSB BFD, CSI-RS based RLM and BFD too. |
| Huawei | Same view as MTK. |
| Apple | If introduced, the K factor could be used for SSB/CSI-RS based RLM and BFD evaluation period. But we don’t understand the justification to extend evaluation for GEO an LEO Earth-fixed satellite. Regarding LEO earth-moving case, the K could be reduced to accommodate the high speed of satellite. Need more discussion if K could be: K= [1] for GEO an LEO Earth-fixed satellite; K= [0.5] for LEO Earth-moving satellite. |
| Xiaomi | We share the similar view as Apple. And we prefer not to relax the requirement for GEO and LEO earth-fixed case in this release due to lack of time. And for LEO earth-moving, K should be reduced due to the high speed of satellite.  And we also have one question for clarification raised many times, If RAN4 introduce different requirement for different satellite deployment. how does UE and/or NW know different satellite deployment, e.g. GEO. LEO earth moving and LEO earth-fixed? |

# 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**

***Tentative 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)

***Further comments:***

* If you have any concern, please be concise and provide your proposal in a form that can be captured in the set of agreements as is.

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| **Company** | **Comments** |
| LGE | We support option 2 in first summary (i.e. the value of K is based on system information). And we think the value of K can be determined by following two sub-options:  Option 2-1: the value of K can be determined by UE  Option 2-2: the value of K can be signaled by NW (we think the value of K can be signaled together with N\_layers since the value of N\_layers is broadcasted in system information)  In the 1st round, some companies commented as “UE does not know whether target measurement cells are TN, GEO, LEO earth moving, or LEO earth fixed”. However, as approved in RAN2 agreement, since neighbour cell satellite ephemeris information is broadcasted, we think UE can distinguish the satellite type. |

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

***Tentative agreement:***

* The maximum interruption in paging reception for NTN cell reselection shall not exceed
  + Option 1:
    - TSI-NR + 2\*Ttarget\_cell\_SMTC\_period, if the target cell belongs to the same satellite as the current one
    - if the target cell belongs to a different satellite than the current one
      * for intra-frequency cell, TSI-NR + 3\*Ttarget\_cell\_SMTC\_period
      * for inter-frequency cell, TSI-NR + 5\*Ttarget\_cell\_SMTC\_period
  + Option 2:
    - TSI-NR + 2\*Ttarget\_cell\_SMTC\_period, when the target cell is known
    - TSI-NR + 5\* Ttarget\_cell\_SMTC\_period when the target cell is unknown.
  + Option 3:
    - 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

***Further comments:***

* Option 3 is added as a compromise between Option 1 and Option 2.
  + Option 1 is supported by Apple (based on further comments received in the second round)
  + Option 2 is supported by Ericsson and Huawei (based on further comments received in the second round)
* Please see if Option 3 is acceptable and share your views. If you have any concern with Option 3, please provide your proposal in a form that can be captured in the set of agreements as is. Of course, a final agreement can be made between Option 1 and Option 2 based on companies’ comments. If no consensus between companies, Moderator suggests Option 3 as a compromise.

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| **Company** | **Comments** |
| Ericsson | We understand the worry on extra delay when the satellites between serving and target are different or are of different types. But we’re aware of the influence of Option 3, this rule may require changes on new cell detection time (in reselection and HO). |
| Huawei | Ok with option 3 as compromise. |
| Apple | Fine with compromise option 3. |
| Xiaomi | Fine with option 3 |

**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.

***Further comments:***

* These are different from legacy spec. Whether we can remove [] may or may not depend on the outcome of Issue 1-5-1-B. And the exact values will be determined later. To proponent of the proposal, it would be appreciated if more detailed analysis than R4-2204724 can be provided in the next meeting.
* Please share any further concerns/comments.

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| **Company** | **Comments** |
| Huawei | Fine with the tentative agreement with []. |
| Apple | We can compromise to the proposal above to protect PO. |

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

***Tentative 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 + GNSS measurement margin’, where GNSS measurement margin is 50 meters

***Further comments:***

* If you have any concern, please be concise and provide your proposal in a form that can be captured in the set of agreements as is.

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| **Company** | **Comments** |
| LGE | Based on following RAN2 agreement,   |  | | --- | | * Location information can be used to determine when to start measurement. |   We also think location condition can be used as measurement trigger condition. But, we think the GNSS measurement margin does not need to be considered since the GNSS error can be considered when NW configure the threshold. Also, depending on the order of the threshold, the 50m margin may be negligible. And since it is first time to discuss this issue, the value of margin needs to be further discussed. So, we propose followings:   * 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 + GNSS measurement margin’, where GNSS measurement margin is [x] meters * Note: the value of x can be [0 50]m |
| Huawei | We understand this issue is about requirements but not UE behavior, and we suggest to capture the following two bullets to address LGE’s comments. On the exact value, we suggest to use 50m, but we are also fine to put it in [] if companies want to further check.   * UE behavior: UE initiates the measurement for cell-reselection in IDLE/Inactive mode if the distance between UE based on GNSS estimated location and serving cell reference location is longer than a ‘network-configured threshold’. * UE requirement: UE initiates the measurement for cell-reselection in IDLE/Inactive mode if the distance between UE based on UE actual location and serving cell reference location is longer than a ‘network-configured threshold + GNSS measurement margin’. |
| Apple | We think the network configured threshold considers the network coverage uncertainty but not the UE measurement/GNSS performance, and it’s very much like the RSRP margin we added in cell reselection requirement.  Thanks Huawei for the suggestions. We would like to clarify our understanding on this margin: UE always assume its GNSS measurement is reliable because UE cannot know how much the real GNSS error is. In order to avoid triggering measurement late, in requirement we can define a GNSS margin on top of the network configured threshold to compensate the uncertainty of UE GNSS measurement, i.e.,  If GNSS error margin is X and UE measured distance between UE and serving cell is D, and the network configured threshold is S, our understanding is UE needs to use ‘D+X’ to compare with S to make sure the measurement would not be triggered late; i.e., compare D with S-X (X is abs(GNSS error)). Then in general it could be:  UE initiates the measurement for cell-reselection in IDLE/Inactive mode if the distance between UE based on GNSS estimated location and serving cell reference location is longer than a ‘network-configured threshold - GNSS measurement margin’. |

## Issue 2-2 HO and CHO

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

***Tentative agreement:***

* DCHO\_NTN = TRRC + Tevent\_DU + Tmeasure + Tinterrupt + TCHO\_execution, where
  + TRRC is the RRC procedure delay.
  + Option 1: 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.
  + Option 2: UE starts RRM measurement when 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 the later of the time when a measurement condition exists at the measurement reference point and the time when a timer/time or location condition (if configured) exists.
    - Tmeasure:
      * NTN measurements time after the end of Tevent\_DU
  + 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 L4” is met and requirements can be reused by replacing legacy condition with “condEvent L4”.
  + General
    - Remove the requirements for the case “undetectable cell becomes detectable again” for NTN CHO.

***Further comments:***

* Options are reorganized based on the feedback from companies. The key differences between Option 1 and Option 2 are, if nor wrong,
  + when UE starts RRM measurement
  + where to include the uncertainty between Tevent\_DU and Tmeasure
* Please share your opinion and indicate your preference.
* The following aspects are removed. If you have a different opinion, please leave your comments.
  + (Intel) the delay includes the timer value and the time difference between serving and neighbour cell SSBs
    - Reason: Reflected in the current options, hence, no need to repeat
  + (Ericsson) Tinterrupt + TCHO\_execution can be later than T2 which are not impacted by expiry of serving cell.
    - Reason: This does not seem consistent with RAN2 agreement
  + (Ericsson) CHO shall not be carried out before T1, TRRC can be earlier than T1 because not RRC signalling will be received after T1.
    - Reason: Reflected in the current options, hence, no need to repeat
  + (Ericsson) Tevent\_DU + Tmeasure shall be in [T1, T2]
    - Reason: Reflected in the current options, hence, no need to repeat
  + (OPPO) The timer-based CHO delay requirements are only applicable when Tmeasure + Tinterrupt + TCHO\_execution > [T2-T1].
    - Reason: Reflected in the current options, hence, no need to repeat
  + (Intel) Do not define test cases for location-based CHO delay requirements
    - Reason: Can be discussed when defining test cases
  + A side condition of ’3200Tc’ in measurement time of conditional handover requirement shall be modified. FFS on the exact value and whether any other side condition is necessary.
    - Reason: Included as part of “Remove the requirements for the case “undetectable cell becomes detectable again” for NTN CHO.”

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| **Company** | **Comments** |
| Huawei | On CHO timeline, we can compromise to option 1.  On Requirement/Test applicability and Others, we have some question related to the following bullet, i.e. what does this mean? Does legacy condition mean RSRP condition? If so, we assume location based CHO has to be in combination with the existing RSRP condition, so should we replace it?   * + For Location-based CHO (in combination with the existing R16 CHO measurement)     - CHO shall only be carried out when “condEvent L4” is met and requirements can be reused by replacing legacy condition with “condEvent L4”.   BTW, based on latest RAN2 CR, it should be condEvent D1. |
| Apple | On CHO timeline, we support option 1 as commented in 2nd round summary.  On Requirement/Test applicability and Others, we agree with HW’s observation and fine with the other parts. |
| Xiaomi | We can compromise to option 1 for CHO timeline. |

**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

***Further comments:***

* The wording is adjusted to clarify this for the original proposal, i.e. UE behaviour is left to UE implementation.
  + “When UE is configured with C (location and RRM) or D (time and RRM) for CHO, UE only measures the SMTC window and frequency layer which the target cell belongs to, if the condition for location or time is met”
* If the clarification is not in line with the original intent of the proposal, please leave comments and share your opinions.

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| **Company** | **Comments** |
| Huawei | We are fine with the modification. |

# 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**

***Tentative 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
  + FFS: introduce UE capability for the number of target satellites the UE can monitor per carrier including serving LEO satellite, which can be up to [4 or 6].

***Further comments:***

* Based on Ericsson comment, FFS is added. If any concern on bullets with FFS is not received, “FFS” will be removed in the final version of WF.
* If you have any concern, please be concise and provide your proposal in a form that can be captured in the set of agreements as is.

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| **Company** | **Comments** |
| Ericsson | We suggest 6 satellites, if more than one satellites can be contained in one SMTC. |
| Huawei | We are fine with the tentative agreement. We can decide the exact value in maintenance. |
| Xiaomi | Fine with the tentative agreement. |

**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 1:
    - If SMTCs do not overlap with each other, a scaling factor of measurement period is
      * Not needed
    - If SMTCs partially overlap with each other, a scaling factor of measurement period is
      * Proportional to the number of overlapping SMTCs
  + Option 2:
    - If SMTCs do not overlap with each other, a scaling factor of measurement period is
      * Not needed; if ,
      * Scaled by X to meet , if
    - If SMTCs partially overlap with each other, a scaling factor of measurement period is
      * Proportional to the number of overlapping SMTCs
      * Also need to check the scheduling restriction overhead like non-overlapped case.

***Further comments:***

* Based on comments, Option 2 is added.
* For those companies supporting Option2, please provide a complete set of details on Option 2. And please also elaborate on the rationale behind the values and formula again in the comment table. If Option 2 can’t be agreed in the meeting, Option 1 would be selected by default.
* For those companies who want to add another option, please provide your proposal in a form that can be captured in the set of agreements as is.

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| **Company** | **Comments** |
| MTK | Provided Option 1a for LEO, to consider the case that multiple LEO satellites within 1 SMTC, as the agreement in the previous meeting (RAN4 101-b) “For LEO, UE is not required to receive signals from multiple satellites/measurement cell groups at one time.”  Option 1a (For LEO):   * 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. |
| LGE | Prefer option 1 |
| Ericsson | Either Option1 or Option 2, UE’s capability shall be added,   * + - If SMTCs partially overlap with each other, a scaling factor of measurement period is       * Proportional to the number of overlapping SMTCs if UE is not capable of parallel measurement of more than 1 satellites in an SMTC.       * 1, if UE is capable of parallel measurement of more than 1 satellites in an SMTC. |
| Huawei | We support option 1a from MTK as we also commented in the second round summary.  To address option 2, we suggest to consider it as applicability condition for option 1/1a, so suggest to add a bullet:  *Introduce scheduling restriction cap as applicability condition for the requirements, details FFS.* |
| Apple | To not diverse the discussion, we can agree with HW’s suggestion that, on top of option 1/1a, we add a bullet to consider the scheduling restriction cap as requirement applicability condition (details could be FFS). |
| Xiaomi | Fine with option 1a, and we also think the scheduling restriction cap should be considered as requirement applicability based on option 1a. |

**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:
    - No requirements are expected for SSB outside of SMTC
  + Option 2:
    - If UE is provided with required information to figure our 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

***Further comments:***

* Based on companies’ comments, Option 2 is prepared to consider a case where UE can properly adjust SMTC window so that target SSBs can fall within the configured SMTC, i.e. effectively SSB inside SMTC.
* If Option 2 receives concerns, Option 1 will be taken as agreement by default. Please feel free to update Option 2. The reason Moderator prepared Option 2 is that leaving it with no-requirement would not be a safer spec design.

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| **Company** | **Comments** |
| LGE | For idle/inactive mode, we prefer to keep FFS or option 1. |
| Huawei | Similar view as LGE.  The problem for option 2 is that so far we do not have measurement requirements for SSB outside of the corresponding SMTC, so we need more time to check the overall spec impacts. |
| Xiaomi | Option 1 |

**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:
    - 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:
    - UE selects the SMTCs based on the RSRP measurements
  + Option 3:
    - 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’

***Further comments:***

* Based on companies’ comments, Option 2 and Option 3 are added.
* In terms of whether gNB can know which SMTCs are selected for measurements, all Options look the same.
* For Option 3, it does not look much different from Option 1. Please clarify the exact difference between the two and check the text in detail.

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| **Company** | **Comments** |
| Ericsson | We understand the difference between Option 1 and Option 3 is: In Option 1, some but not all SMTCs can be determined by UE for measurements; in Option 3, UE shall sweep all SMTCs configured by network equally.  Option 2, we preference, was derived based on moderator’s suggestion in 1st summary, to clarify FFS in Option 1. The detailed solution is ‘If the number of configured SMTCs exceed the UE capability, then UE selects the SMTCs based on the RSRP measured . For example, UE supporting 2 SMTCs, selects up to two SMTCs whose RSRP is above a threshold after determination all SMTCs if 4 SMTCs are configured by network.’ |
| Huawei | We support option 3 as a safer choice.  The difference between option 1 and 3 is that in option 3 all SMTCs are measured (though with longer delay), but in option 1 only a subset of SMTCs are measured. |
| Apple | We support option 3. Option 1 didn’t actually mention UE shall sweep all the SMTCs equally and therefore UE may not measure some SMTCs throughout the measurement time (e.g., if SMTCs for LEO and GEO configured, but UE always chooses SMTC associated with GEO for measurement) and network cannot determine which SMTCs would be ignored by UE. |

**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
  + The following aspects will be additionally introduced
    - FFS: Selection between ‘Priority rule between concurrent MGs’ and ‘Scalling factor due to overlapping MG’

***Further comments:***

* Regarding ‘scaling factor’ vs. ‘priority rule’, to Moderator’s understanding, alternating patterns can be created even using ‘priority rule’ if needed. For those supporting ‘scaling factor’ please provide all the details.

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| **Company** | **Comments** |
| MTK | Regarding ‘Scalling factor due to overlapping MG’, in our views those MGs are corresponding to different satellites and have equal priority. If we adopt priority rule with different priority, then some satellite may not got chance to be measured if those MGs are fully overlapped. Thus we suggest ‘Scalling factor due to overlapping MG’. |
| LGE | For Rel-17 NTN, we prefer to define requirements with MGs in case there is no overlapping between MGs since priority solution of Rel-17 MG enhancement when MGs are overlapped is not clear to apply NTN case. If the case of overlapping is considered, we prefer to use scaling factor for this case. |
| Ericson | Maybe it’s too early to get agreements on ‘scaling factor’ vs. ‘priority rule’. Our intention is the rule between concurrent MGs shall not preclude other options besides of the only ‘priority rule’ in current MG session, especially when two MGs are for NTN. |
| Huawei | We can compromise to the “scaling factor” approach if it is preference of majority. In our view, it is same as the “sharing rule” as discussed in concurrent MG. |
| Apple | We support to use “Scalling factor due to overlapping MG”. But we are fine to further discuss if some special MG usage case shall be prioritized. |
| Xiaomi | We support to use “scaling factor” approach. |

## 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**

***Tentative agreement:***

* If essential information for NTN neighbour cell measurement is not provided,
  + Option 1:
    - SIBx reading time added to the measurement period
  + Option 2:
    - SIBx reading time is needed but not added to the measurement period
  + Option 3:
    - No requirement is applied

***Further comments:***

* The issue is related with Issue 1-6-1. Please keep consistency in making comments on both Issues.
* For those supporting Option 1 and Option 2, please also explain whether and how UE can obtain essential information for neighbour cell measurement from serving cell’s SIB.

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| **Company** | **Comments** |
| MTK | We support Option 1 not for the case that if essential information for NTN neighbour cell measurement is not provided (Issue 1-6-1), but for the case the essential information is in deeded provided, but UE may need to read “serving” SIBx regularly to get the essential information for NTN neighbour cell measurement.  The intention is that the measurement requirement applies given the SIB info is provided and decoded by the UE. Otherwise, it will be ambiguous that UE is required to fulfill the measurement requirement even when the SIB info is not yet decoded/available by the UE.  Since the information is essential for measurement, we suggest to clarify such as “the measurement requirement applies, provided the essential information for NTN neighbour cell measurement is provided and has been decoded at the UE”. |
| Ericsson | Option1, we suggest available requirements when no neighbour cell ephemeris data is not provided by serving cell, instead of no requirements or limitations. |
| Huawei | We support option 3.  When commenting in the summary, we missed the high level condition of the issue (If essential information for NTN neighbour cell measurement is not provided). |
| Apple | We support option 3.  RAN2 answer: RAN2 assumes all the information needed for measurement and handover would be provided to the UE by the network. If any of the information is not available or is not valid, then the UE would have to acquire the system information of the target or neighbor cell which is not desirable from handover interruption time point of view.  Our understanding to RAN2 LS is: all the information needed for measurement would be provided to UE, but after provided them to UE, some of them might be out of date or invalid.  So, if any of essential information is not provided to UE, no requirement shall be applied. |
| Xiaomi | We support option 3, the same comments as in issue 1-6-1. |

# Topic #4: UE Capability

## Issue 4-1: NTN UE Capability

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

***Tentative agreement:***

* The following NTN UE capabilities are defined as optional capability unless otherwise stated:
  + 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
    - FFS mandatory vs. optional capability
  + 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
    - Up to 4 satellites
  + support 2 MGs
  + Support performing measurements on different numbers of target cells within multiple SMTCs on a single carrier
  + Support different numbers of 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

***Further comments:***

* Please provide your opinion on each bullet. If you see items overlapping each other, please indicate them in the comment table.

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| **Company** | **Comments** |
| MTK | Below two are over-lapped in our view, because the measurements on neighbor cells are within SMTC.   * Parallel measurement of LEO in one SMTC * Perform measurements on more than one neighbor cells belonging to different satellites in parallel without scaling.   Below two are over-lapped in our view, the UE capability can be based on the numbers of parallel measurement gaps.   * support 2 MGs * Support different numbers of parallel measurement gaps   Below two are over-lapped in our view, while the 2nd bullet provide more description.   * Parallel measurement and normal operation * Support performing measurements on cells belonging to different satellite as the serving cell at the same time with normal operations in serving cell |
| Ericsson | * + Parallel measurement and normal operation     - Support optional capability   + Parallel measurement of LEO in one SMTC     - Support optional capability   + Support enhanced (e.g. TN HST) Idle/Inactive mode cell reselection requirements for LEO     - It is mandatory, shall we add it into capability?   + (GTW agreement) Perform measurements on cells belonging to different satellite as the serving cell in parallel with normal operation of serving cell without scheduling restrictions.     - Same as Parallel measurement and normal operation   + Perform measurements on more than one (suggest 2) neighbor cells belonging to different satellites in parallel without scaling.     - Same as Parallel measurement of LEO in one SMTC?   + Measurement for more than 2 (suggest 4) LEO satellites per carrier     - Support , but suggest 6   + (GTW agreement) support 2 MGs     - Support   + Support performing measurements on different numbers of target cells within multiple SMTCs on a single carrier (RAN2 mandated 2 and made 4 optional)     - Support   + Support different numbers of parallel measurement gaps     - Is it same as (GTW agreement) support 2 MGs?   + Support performing measurements on cells belonging to different satellite as the serving cell at the same time with normal operations in serving cell     - Same as Parallel measurement and normal operation |
| Huawei | Same view as MTK on overlapping between the items.  We support all of them after combining the overlapping items. |

# References

[1] R4-22xxxxx, “Email discussion summary: [102-e][220] NR\_NTN\_solutions\_RRM\_1,” 3GPP TSG-RAN WG4 Meeting #102- e