3GPP TSG-RAN WG2 Meeting #124 R2-230xxxx

Chicago, US, November 13-17, 2023

Agenda Item: 7.7.4.2

Source: CMCC/Apple

Title: Report of [Post123bis][312][NR-NTN Enh] Unchanged PCI (CMCC/Apple)

Document for: Discussion and Decision

# 1 Introduction

In RAN2 #123bis meeting, there were some fruitful discussions about unchanged PCI. However, there are still some open issues needed further discussion.

This document captures the outcome of the following discussion in order to address all the open issues.

* [Post123bis][312][NR-NTN Enh] Unchanged PCI (CMCC/Apple)

Scope: Continue the discussion on unchanged PCI specific aspects

Intended outcome: email discussion summary

Deadline: Long

Please provide your comments before October 26th 0100 UTC.

# 2 Discussion

## 2.1 Configuration (Part A)

### **Issue 1: Target satellite information**

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| RAN2#123bis agreement:   * *Only 1 target satellite information (i.e. NTN-config) of serving cell is provided in SIB19. FFS on exact signalling* |

Regarding the target satellite information, RAN2 agreed that only 1 target satellite information (i.e. NTN-config) of serving cell is provided in SIB19 with the FFS on exact signaling.

About the exact signaling in detail, there are several options proposed during offline discussion:

* Option 1: Introduce one new target satellite configuration (e.g. *ntn-TargetSatConfig*), and provide the *NTN-config* of the target satellite in it.

Following is one ASN.1 example.

A screenshot of a computer

Description automatically generated

* Option 2: Introduce one new target satellite configuration (e.g. *ntn-TargetSatConfig*), but for the provision of the target satellite’s *NTN-config*, it is not explicitliy provided in it, but rely on a pointer (e.g.targetSatInfo) to *NeighCellConfigList* (e.g.targetSatInfo) to aquire the NTN-config of the target satellite.

A screenshot of a computer

Description automatically generated

* Option 3: Just extend the additional information for hard/soft switch in the existing *NTN-NeighCellConfig* as follows:



* Option 4: Others?

#### **Question A1: Please provide your preferred options on the specific signaling format about the target satellite information in SIB19**

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| --- | --- | --- |
| **Company** | **Preferred Option** | **Comments** |
| Ericsson | Option 1 variation | As proposed in the running RRC CR, Option 1 is more compact and specifically addresses this new feature. SSB information can be added later when agreed.  SatSwitchWithReSync-r18 ::= SEQUENCE {  ntn-Config-r17 NTN-Config-r17 OPTIONAL, -- Need R  t-serviceStart-r18 INTEGER (0..549755813887} OPTIONAL -- Need R  } |
| Samsung | Both Option 1 and 2 | Both option 1 and 2 should be allowed. If the target satellite info is not in *NeighCellConfigList*, option 1 or the current CR is fine, if the targe satellite is one satellite that provides neighbor cells in *NeighCellConfigList*, by option 2 duplication can be avoided. |
| CATT | Option1 | For option 2, if the target satellite info is provided in the NTN neighbour cell list, the IDLE/INACTIVE may need to perform measurement on the target satellite that has not arrived.  For option 3, we don’t see the necessity of introducing an new *NTN-NeighbourCellConfig* for Rel-18. |
| vivo | Option 1 | The assistance information is the content for the further target satellites, which is independent of the neighbor cell. In this sense, we don't think it's appropriate to use an element of the neighbor cell list to represent the target satellite information (i.e. Option 2 is not acceptable).  For option 3, a list of target satellites is not needed since RAN2 agreed that only 1 target satellite information (i.e. NTN-config) of serving cell is provided. |
| Qualcomm | See comments (option 1) | Now we wonder if it was right thing to broadcast this info in SIB19 as this is just happening once only at t-Service but SIB19 would have to be updated and broadcast frequently. It could have been in other SIB.  Option 1 seems the simplest one but we think it should be clarified whether the UE needs to acquire new satellite SIB19 or not to trigger RACH. |
| Lenovo | Option 1 | Option 1 is simplest, and the new IE can be an implicit indication for PCI unchanged. |
| ZTE | Option 1 | It is a cleaner solution |

**Summary:**

### **Issue 2 Target satellite SMTC aspects**

For the additional information distributed in the system information, SMTC configuration of target satellite is needed based on some companies comments, as in the F2F offline discussion [2], the following issues are raised and need further discussion:

* + Is the SMTC configuration of the target satellites the same or different from the source? *Notes: the answer can be respectively provided for the hard switch and soft switch.*
  + Is the SMTC adjustment handled by network or by UE?
  + How to provide the SMTC configuration of the target satellite if it’s different?

#### **Question A2-1 : Do you think the SMTC configuration of target satellite can be different from that in source?**

* + *Notes: the answer can be respectively provided for the hard switch and soft switch.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes/No**  **（for hard switch）** | **Yes/No**  **（for soft switch）** | **Comments** |
| Ericsson | No | Yes | For soft switch, there is no technical reason precluding SMTC to be the same as long as different cells use separated SSB indexes to avoid collisions. |
| Samsung | Yes | Yes | If PDD is changed, smtc can be different regardless of hard or soft switch, but the new smtc can be reconfigured by NW as legacy for UE in connected mode. |
| CATT | See comments | See comments | For hard satellite switchthe NW does not need to broadcast SSB via source satellite and target satellite with difference. Hence, the UE could estimate the time window of SSB provided by the target satellite based on the ephemeris and common TA info autonomously.  For soft satellite switch, the NW may configure the target satellite broadcast SSB with an offset compare with source satellite to avoid interference. So the NW could send the SSB with a time offset comparing with the source satellite.  Especially for the soft switching case, we think there is potential overlap between the SMTC configuration in this question and time offset option in QA4-1. |
| vivo | Yes, but | Yes, but | We are wondering about the motivation of this question.  The SMTC configuration is totally up to NW, that is NW can reconfiguration the configuration at any time in any case. So the NW of course can have different configurations for source and target. But generally, the same configuration should be used considering the gNB configuration is not changed in the unchanged PCI case.  In our understanding, the issue herein is how to efficiently measure the target satellite (i.e. DL sync with the target) using the configured SMTC configuration (with potential adjustment) or other SMTC configuration. |
| Qualcomm | Yes | Yes | Change of satellite means in both cases, the SMTC offset could be different. |
| Lenovo | Yes | Yes | We think there is no need to restrict or differeciate. |
| ZTE | No | Yes | There is no enhancements needed for hard switch. For soft switch case it is possible that the SMTC from source and target could be different or the same, but in any case UE can based on common TA and ephemeris info in SIB19 to calculate PDD and adjust the SMTC autonomously. |

#### **Question A2-2 : Do you think the SMTC configuration adjustment should be handled by network or by UE?**

* Option 1: network control

If network handles the SMTC configuration adjustment, UE does not need to adjust the SMTC configuration of the target satellite based on the PDD.

* Option 2: UE control

If UE handles the SMTC configuration adjustment, UE needs to perform the adjustment based on the PDD between source SAT and target SAT, and the behavior is similar as that in IDLE/INACTIVE operation.

* Option 3: other?

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| **Company** | **Option** | **Comments** |
| Ericsson | Option 2 | A similar behavior as in RRC\_IDLE/INACTIVE should be followed. UE should adapt SMTC to its location with the use of ephemeris and common TA parameters. Otherwise, dedicated signaling for SMTC configuration is needed which increases signaling overhead and makes the unchanged PCI procedure not transparent which was the initial objective. |
| Samsung | Option 3 (no need to broadcast smtc) | For neighbor cell measurement, SMTC is given because UE is not synchronized with the neighbor cell and it has to measure SSBs within the indicated smtc window.  While for the serving cell, UE has to synchronize with the serving cell by searching SSBs. Therefore, similar to performing HO where *ssb-PositionsInBurst* and ssb-periodicityServingCell are given in ServingCellConfigCommon, *ssb-PositionsInBurst* for the target satellite should be provided in SIB19 so that UE can search the SSB based on the SSB pattern, assuming ssb-periodicityServingCell shall not change for the same serving cell. The offset caused by PDD can be calculated by UE based one target satellite ephemeris and handled by UE based on serving cell existing smtc. So no need to broadcast additional smtc. |
| CATT | See comments | For the hard satellite switch, the measurement timing window of the SSB via the target satellite can be adjusted by UE autonomously by the ephemeris and common TA parameter.  For the soft satellite switch, the UE measurement timing window of the SSB via the target satellite is adjusted by UE based on the time offset configured by NW (as mentioned in QA2-1). |
| vivo | Option 2 | For Opt1, it seems infeasible. Assistance information (e.g., PDD between source satellite and target satellite) is needed from UE. However, UE cannot report PDD between source satellite and target satellite to the NW before the target satellite appears, which means the NW can not provide SMTC configuration in advance (i.e., before the target satellite appears). If the network-based solution is applied, the latency of accessing the target satellite will increase, because the UE reports the PDD between source satellite and target satellite after the target satellite appears and then the NW provides SMTC configuration, then UE can synchronize with the target satellite.  Opt2 is more reasonable. |
| Qualcomm | Option 2, see comments | It seems UE would have to adjust the SMTC offset for the target. We need to discuss whether the UE provides the updated SMTC to network or trigger PDD report, otherwise UE and network may be out of sync once UE resumes UL/DL. |
| Lenovo | Option 2 | Prefer to have similar behavior to RRC\_IDLE. |
| ZTE | Option 2 | Since UE will have to reacquire SIB19, it is possible for UE to adjust SMTC autonomously based on the derived propagation delay. |

#### **Question A2-3 : If SMTC configuration is different from source and target satellite, do you think the SMTC configuration of target satellite should be provided in SIB19 or in RRC dedicated signaling in advance?**

* Option 1: provided in SIB19
* Option 2: provided in RRCReconfiguration before SAT switching
* Option 3: others?

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| **Company** | **Option** | **Comments** |
| Ericsson | Option 1 | Same reasoning as in A2-2. |
| Samsung | Option 3 (no need to broadcast smtc) | For neighbor cell measurement, SMTC is given because UE is not synchronized with the neighbor cell and it has to measure SSBs within the indicated smtc window.  While for the serving cell, UE has to synchronize with the serving cell by searching SSBs. Therefore, similar to performing HO where *ssb-PositionsInBurst* and ssb-periodicityServingCell are given in ServingCellConfigCommon, *ssb-PositionsInBurst* for the target satellite should be provided in SIB19 so that UE can search the SSB based on the SSB pattern, assuming ssb-periodicityServingCell shall not change for the same serving cell. The offset caused by PDD can be calculated by UE based one target satellite ephemeris and handled by UE based on serving cell existing smtc. So no need to broadcast additional smtc. |
| CATT | See comments | As per our replies in QA2-1 we think the SMTC in this question is coupled with the time-offset option in Question A4-1. So whether to configure offset/SMTC depends on the conclusion of QA4-1.  If we agree to configure time offset/SMTC, e.g., for soft satellite switch case, the info should be provided in SIB19. |
| vivo | Comments | As per our reply in Question A2-2, SMTC configuration of target satellite cannot be provided by the network in advance. UE-based adjustment is preferable. |
| Qualcomm | Option 1 | We should avoid any dedicated signaling for this solution. |
| Lenovo | Option 1 |  |
| ZTE | Option 3, no need to provide SMTC configuration | Per our comments in QA2-1-QA2-2, there is no need to broadcast SMTC, UE can adjust it autonomously. |

### **Issue 3: Hard or soft switch indication**

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| RAN2#123bis agreement:   * *Only 1 target satellite information (i.e. NTN-config) of serving cell is provided in SIB19. FFS on exact signalling* |

#### We agreed to introduce an indication to inform UE it is hard switch or soft switch case, with FFS if explicit or implicit.

#### **Question A3: Please provide your preferred indication manner, explicit or implicit?**

* Option 1: explicit indication, i.e. 1 bit indication whether it’s the soft switching or hard switching
* Option 2: implicit indication via the presence of T-start related configuration, e.g. soft switching if T-start is configured.
* Option 3: Other?

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| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| Ericsson | Option 2. Implicit. | The value of t-start w.r.t. t-service is sufficient indication for the type of switch. |
| Samsung | Option 2 | Agree with Ericsson, t-start with an earlier time than t-service indicates soft switch, t-start with the same value as t-service indicates hard switch. For hard switch, t-start can also be used as the trigger for switch. |
| CATT | Option 2 | If t-start is absent, the case is hard satellite switch with coverage gap is zero. Otherwise, the case is soft satellite, and the start serving time of the target satellite is t-start. |
| vivo | Option 2 | The presence of T-start can implicitly indicate that soft satellite switching will happen. |
| Qualcomm | Option 2 |  |
| Lenovo | Option 2 | T-start (and possibly its relation with t-Service) is sufficient. |
| ZTE | Option 2 |  |

**Summary:**

### **Issue 4: Target satellite SSB aspects**

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| RAN2#123bis agreement:   * At least soft satellite switching, network provides SSB information of target satellite to UE. FFS on the details: options include e.g. indicating a time offset/information or indicating a different SSB index for the target satellite (FFS for Hard satellite switch) |

At least soft satellite switching, network provides SSB information of target satellite to UE is agreed. And the detail target SSB information is FFS, and the following options could be the discussion baseline based on our discussion in RAN2 #123bis meeting:

**Option 1:** Indicating a time offset/information for the target satellite

**Option 2:** Indicating a different SSB index for the target satellite

#### **Question A4-1: Please provide your preferred option about target satellite SSB information in soft switch.**

**Option 1:** Indicating a time offset/information for the target satellite

**Option 2:** Indicating a different SSB index for the target satellite

**Option 3:** Other?

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| **Company** | **Preferred option** | **Comments** |
| Ericsson | Option 2 | From RAN1 LS, network can solve by implementation the SSB collision for the soft switch scenario. However, the way in which the problem is solved determines the type of signaling that RAN2 needs to design.  We think that there is no need to change SMTC configuration upon the cell switch. Hence, Option 2 is more efficient and aligned with current design: bitmap based on SSB index to indicate which SSB is transmitted/should be measured. |
| Samsung | Option 3 (*ssb-PositionsInBurst* of the target satellite) | *ssb-PositionsInBurst* gives the SSB pattern, it indicates the time domain positions of the transmitted SS-blocks in a half frame with SS/PBCH blocks as defined in TS 38.213 [13], clause 4.1. It also allows NW to indicate a different set of SSB indexes for the target satellite. |
| CATT | Option 1 | For option 2, configure different SSB index for the target satellite may cause reconfiguration of SSB configuration related info, e.g., TCI state, after satellite switching. And this, in the other way around, eats up the overhead saving brought by the unchanged PCI operation.  For example, the SSB indexes configured for source satellite are #0 and #1, so the TCI state is associated with SSB index #0 and #1. If the SSB index configured for target satellite are #2 and #3, the TCI state should be reconfigured to be associated with SSB index #2 and #3. This will result in RRC reconfiguration procedure which does not fit with the motivation of unchanged PCI. |
| vivo | Option 2 | In our understanding, Opt 1 is infeasible. This is because a cell-specific offset cannot precisely compensate UE’s specific PDD. As a result, the UE cannot distinguish whether an SSB is from source or target due to the overlapping.  For Op2, after satellite switching, the NW can send MAC CEs to update the TCI state/Pathloss reference/Spitial relation (i.e. the NW preconfig TCI state/Pathloss reference/Spitial relation for both source and target, and use MAC CE to update the state). RRC reconfiguration is not needed. |
| Qualcomm | Option 1+Option 2 | After further think, it seems SSB index indication is not very critical. What is critical for faster SSB detection is what is time offset of the SSB at ULSRP between source and target satellite, then UE will detect the SSB. In this sense, option 1 is sufficient.  However, Option 1 + Option 2 is also useful in case of multiple SSBs from target and network wants UE to select a specific SSB. |
| Lenovo | Option 2 | A different SSB index is straight-forward. |
| ZTE | Option 2 | Same view as Ericsson |

**Summary:**

Then for hard satellite switch, there is no interference issue between source and target satellite, maybe we could consider to keep flexibility and whether provide target SSB information is up to NW implementation. If NW provide target SSB information, the same mechanism as in soft satellite switch is adopted.

#### **Question A4-2: For hard satellite switch, do companies agree the same SSB information of the target satellite should be provided?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Ericsson | No | This is not necessary. SSB information does not need to change upon a hard switch since there are no collisions. Even if it does change, legacy mechanism such as *ssb-PositionsInBurst* and *ssb-ToMeasure* shall be used to indicate the SSB information. |
| Samsung | Yes | *ssb-PositionsInBurst* for the target cell can be provided if SSB information is changed for hard switch, and it shall be provided for soft switch. |
| CATT | No | For hard satellite switch, the NW does not need to broadcast SSB via source satellite and target satellite with an offset. Hence, the UE could estimate the time window of SSB provided by the target satellite based on the ephemeris and common TA info.  The mechanism to be concluded for soft satellite switch is not needed in hard satellite switch case. |
| vivo | No | Same view with Ericsson. For hard satellite switch, there is no interference issue between source and target satellite regarding the SSB detecting. |
| Qualcomm | No |  |
| Lenovo | No | Not needed for hard switch. |
| ZTE | No |  |

**Summary:**

### **Issue 5: T-start aspects**

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| RAN2#123bis agreement:   * We introduce a T-start which indicates the earliest occasion when the UE can start synchronizing with target satellite (actual signalling is FFS). In soft switch scenario, T-start of target satellite is earlier than T-service of source satellite (FFS if T-start is also used for hard satellite switch) |

We agreed to introduce a T-start which indicates the earliest occasion when the UE can start synchronizing with target satellite for soft satellite switch case with FFS actual signaling, and T-start of target satellite is earlier than T-service of source satellite.

#### **Question A5-1: Please provide your comments on FFS actual signaling about T-start for soft satellite switch.**

**Option 1:** Introduce the new configuraiton of T-start

**Option 2:** Introduce the new configuraiton of T-gap, UE can aquire the T-start of target satellite based on T-gap and T-service of source satellite. (T-start = T-service – T-gap).

**Option 3:** other?

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| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| Ericsson | Option 2 | T-gap of ASN.1 type INTEGER is a more flexible approach which can cover a range of scenarios. For instance, T-gap=0 may indicate immediate hard switch (negligible interruption), T-gap>0 can indicate a small coverage interruption, and t-gap<0 indicates soft switch. |
| Samsung | Option 1 | T-start is more straightforward, that can indicate any time before, equal to, or after t-service, and does not depends on t-service. |
| CATT | Option 1 | If option 1 is adopted, the format of t-Start can be determined quickly. It can be defined in format of UTC, same as the *t-Service*, shown below.  t-Service-r17 INTEGER (0..549755813887) OPTIONAL, -- Need R  But if option 2 is adopted, we need to discuss the value range and step of t-Gap, which may need checking with RAN1.  Considering that we only have one meeting left and there are a lot of essential issues to discuss, we support option1. |
| vivo | Option 1 | Option 1 is more straightforward. |
| Qualcomm | Option 2 | Option 1 adds overhead. Option 2 seems reasonable as this gap is supposed to be small. We prefer not to have positive gap for HARD satellite switch to avoid any impact to other working groups.  As long as the range we define for the gap is small, and keep spare values for future extension of larger values, the positive gap is fine. |
| Lenovo | Option 1 | T-start is more straight-forward and is also flexible even than the t-gap which could be limited by value range. |
| ZTE | Option 1 | Share the same view as Samsung and CATT |

**Summary:**

#### **Question A5-2: Do you think T-start should be also provided for hard satellite switch?**

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| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Ericsson | Yes | We don’t see any technical reasons to preclude using t-start/t-gap in hard switches. |
| Samsung | Yes | T-start equal to t-service can indicate a hard switch. As we have agreed for hard switch, a switch trigger indication is needed on top of t-service, t-start can be used as the switch trigger. In this way, we allow a unified procedure of hard and soft switch. |
| CATT | No | We have no time to consider the case of hard satellite switch with coverage gap is not zero. |
| vivo | No | RAN2 has agreed that t-Service is used for hard satellite switch, there is no need to introduce other mechanisms. Moreover, the presence of T-start can be used by UE to decide whether is hard satellite switch or soft satellite switch case. |
| Qualcomm | No | We prefer only negative gap for now and avoid complexity of work. Small positive gap can be ignored. |
| Lenovo | Neutral | We are fine to have no restriction on this (in case other scenario e.g., T-start is late than T-service, is considered in future) |
| ZTE | Yes | Since T-start is needed for soft switch, it could be possible to use it as well for hard switch (by configuring the same value as t-service), which means unified UE behavior to reacquire SIB19 for both soft/hard switch satellite change. In such case, presence of target satellite info/SSB info in PCI unchanged scenario will be implicit indication that it is for soft satellite switch. But this also implies reverse of previous agreements that t-start shall be earlier than t-service. |

**Summary:**

## 2.1 UE operation (Part B)

### 2.2.1. UE operation during the satellite switching procedure

For both RACH-based and RACH-less satellite switching procedure, the change of serving satellite will lead to changes in the propagation delay and the channel condition of the serving cell from UE perspective. Therefore, it will introduce some impact on MAC operation and RRM measurement operation.

Regarding the impact on MAC operation, due to the pathloss change, UE may need to report the PHR based on new pathloss after satellite switching.

**Proposal 1: During satellite switching procedure, UE initiates PHR reporting after satellite switching.**

#### **Question B-1: Do you agree with the proposal 1?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | Rely on legacy PHR triggering is sufficient. |
| Samsung | No | Agree with Ericsson |
| CATT |  | The UE reports PHR after satellite switching, if path loss has changed more than a threshold, e.g. *phr-Tx-PowerFactorChange*.  But we keep it open on whether this is an essential feature having to be introduced at this stage. |
| vivo | No | The legacy trigger condition can be reused for PHR reporting (i.e. the pathloss is changed beyond threshold), no new trigger condition is needed. |
| Qualcomm | See comments | However, the UE should trigger TA report MAC CE or PDD report. For PHR we also think legacy mechanism is sufficient. |
| Lenovo | No | legacy PHR triggering is ok |
| ZTE | No | Agree with Ericsson |

Regarding the impact on RRM measurement, due to the change of radio condition of the serving cell, UE may need to reset all the serving cell related measurement , i.e. reset L3 filter for the serving cell’s RRM measurement and reset RLM, but there will be no impact on neighbor cell’s measurement.

**Proposal 2: During satellite switching procedure, UE re-initiates all the serving cell related measurement, e.g. reset L3 filter for serving cell RRM measurement and reset the RLM.**

#### **Question B-2: Do you agree with the proposal 2?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | See comments | We understand the reasons behind the proposal, but it is unclear to us where or how to capture this behavior in the specification. In legacy, UE is not mandated to discard samples as the UE knows that the "old samples" of the old serving cell may be reported as neighbor cell later after handover completion. Here, the situation is different; we assume that *measConfig* does not need to be released since source and target cell are the same cell, and the configuration is generated by the CU which does not change. However, there should be a common understanding between UE and network of where *measObject* reported samples come from. |
| Samsung | Yes |  |
| CATT | Yes |  |
| vivo | No | After satellite switching, the measurement results generally become better, and then “IS” will be indicated to clear RLF. There is no bad consequence even though the UE doesnot reset RRM or RLF. Moreover, the NW knows when satellite switching happens, it can be based on the NW implementation not using the measurement report for the serving cell under such a case.  We fail to see a big motivation to have this enhancement. |
| Qualcomm | Yes, see comments | It may be better not to use old satellite measurements for L3 filtering. However, this should not impact the measurement variables and reporting, i.e., only about L3 filtering window. |
| Lenovo | Yes with comments | We think this can be UE implementation. |
| ZTE | See comments | If it is up to UE implementation, there seems no specs impact. |

A failure detection timer should be introduced to protect the failure case, which is similar as HOF timer (T304). The timer is started when UE starting the satellite switching and stopped when the sync procedure successful to the target satellite is successfully completed. When the failure timer expires, UE will initiate the UE connection reestablishment procedure.

**Proposal 3: Introduced timer based failure detection mechanism for satellite switching procedure.**

**Proposal 4: When the satellite switching failure is detected, UE initiates the UE connection reestablishment procedure.**

#### **Question B-3: Do you agree with the proposal 3?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | The premise of supporting this feature is not to introduce a switching procedure requiring the UE to send switching complete message to confirm the switch and have minimum spec impact. Legacy mechanisms (RLF and Re-establishment) not specific for mobility procedure apply, no need for enhancements. |
| Samsung | No | Legacy RLF and RRC re-establishment can work. |
| CATT | No | A new timer is not needed. The failure detection of the unchanged PCI procedure can be well handled by current RLF mechanisms, e.g., T310 and max number of preamble transmission. |
| vivo | Yes | Upon service link switching occurs, all the UE in the cell needs to re-synchronize to the new satellite. Due to the limited resources on the network side, there is a high probability that one RACH process will fail for UEs at the cell edge or UEs with poor coverage. If we rely on RACH failure to determine satellite switching procedure failure, these UEs have a high probability of experiencing satellite switching procedure failure and then performing RRC connection re-establishment in the cell where the failure occurred. In order to save signaling overhead to a greater extent, timer based failure detection mechanism should be introduced. |
| Qualcomm | No but see comments | As long as we define UE should trigger to report TA report MAC CE or PDD report upon successful satellite synchronization to let network know UE is ready, existing RLF mechanism works. |
| Lenovo | No | And we agree with Qualcomm that UE should trigger TA report upon successful satellite synchronization. |
| ZTE | No | We can relay on legacy RLM procedure |

#### **Question B-4: Do you agree with the proposal 4?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | See answer to B-3. Legacy mechanisms apply. |
| Samsung | No | Satellite switch failure can be detected by RLF and RRC re-establishment can work. |
| CATT | Yes | Follow current RLF procedures. |
| vivo | Yes |  |
| Qualcomm | No | See our response in B-3. |
| Lenovo | No |  |
| ZTE | No |  |

### 2.2.2.RACH-less satellite switching

RAN2 agreed to support satellite switching without RACH procedure. To support this RACH-less satellite switching procedure, some open issues need to be addressed.

1. UE capability

From UE capability perspective, the support of NR RACH-less HO is optional. . Similarly, the support of RACH-less SAT switching should be also defined as optional UE capability.

**Proposal 5: It’s the optional UE capability to support the RACH-less satellite switching procedure.**

#### **Question B-5: Do you agree with the proposal 5?**

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | Unchanged PCI RACH-less is not a feature that the network will configure. In fact, there is no dedicated configuration for this kind of unchanged PCI switch. Hence, the use of RACH-less is up to UE implementation. If the UE has already a configured grant and can calculate and pre-compensate TA, then it can use RACH-less access in the target satellite. If the UE does not already have a configured grant, the gNB could issue a dynamic grant after the UE acquires sync of the target satellite, by this the UE also needs not to perform RACH in the target satellite. |
| Samsung | No | We think only a UE capability of PCI unchanged satellite switch is needed. RACH-less switch does not require additional UE capability because it’s within the same serving cell and whether RACH is performed or not is per NW configuration. If NW indicates rach-based switch, UE initiates RACH when switching to the target satellite; if NW indicates rach-less switch (e.g., by giving N\_TA), UE does not perform RACH and re-synchronize by using N\_TA. |
| CATT | Yes | And it should be a capability with signalling. The NW needs to know which UE should be scheduled after successful RACH. |
| vivo | No | Satellite switching without RACH procedure is not the same as RACH-less satellite switching procedure. We don’t support RACH-less satellite switching.  In our understanding, the main scenario in which satellite switching without RACH procedure is that the RTT of UE does not change after service link switching, UE does not need to re-synchronize to the serving cell. In other words, the satellite switch is senseless for UE, no new UE behavior is not needed. |
| Qualcomm | No | We also think this is just about whether to transmit UL signal in the configured resources or trigger RACH to inform network. These are existing procedures. |
| Lenovo | No |  |
| ZTE | No | NW can based on unchanged PCI capability to decide whether to to schedule UE with or without RACH. There is no additional capability required for UE to skipped RACH in this case. |

1. Network configuration

From network side, whether to enable the RACH-less satellite switching should be based on network configuration. Since the satellite switching is not L3 based mobility, using RRC dedicated signaling for such configuration should be avoided as much as possible, and we can only rely on SIB19 to provide such configuration.

**Proposal 6: RACH-less satellite switching procedure is configured in SIB19.**

#### **Question B-6: Do you agree with the proposal 6?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | Same reasoning as in B-5. |
| Samsung | Yes | N\_TA for RACH-less PCI unchanged switch should be provide in SIB19. |
| CATT | Yes |  |
| vivo | No | See our reply to Question B-5. |
| Qualcomm | No but see comments | But we need to discuss whether there is forced RACH trigger upon satellite switch. This anyway can be provided in HO command. |
| Lenovo | No |  |
|  |  |  |

When UE receives the SIB19 with RACH-less satellite switching configuration, if UE doesnot support RACH-less procedure, UE will still perform RACH-based satellite switching procedure.

**Proposal 7: If UE does not support RACH-less satellite switching, UE will only perform RACH-based procedure regardless of whether the network configured RACH-less or RACH-based satellite switching procedure.**

#### **Question B-7: Do you agree with the proposal 7?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | This proposal is formulated under the assumption that B-5 and B-6 are agreed. If the network wants the UE to perform RACH, it can just send a PDCCH order after the switch, otherwise it can issue a dynamic grant or let UE continue to use CG if already available. |
| Samsung | No | See B-5 |
| CATT | Yes |  |
| vivo | No | See our reply to Question B-5. |
| Qualcomm |  | It is not clear if there was any new specific different behavior other than existing PUSCH/PUCCH vs RACH triggers, which requires new UE capability. |
| Lenovo | No |  |
|  |  |  |

1. UE operation during RACH-less satellite switching

* UL grant for the 1st UL transmission towards target satellite

During RACH-less satellite switching, in order to provide the UL grant for the 1st UL transmission towards target satellite, we can follow the same design as RACH-less HO and rely on dynamic grant or pre-configured grant.

* Option 1: dynamic grant

In RACH-less HO, network can provide UE the beam for the dynamic grant reception from the target cell in RACH-less HO command.

For satellite switching scenario, since the serving satellite changes, the beam situation providing coverage has also changed. In this procedure, the beam information should be cell specific or satellite specific, so network can provide the beam information for the dynamic grant reception in target satellite in SIB19.

* Option 2: preconfigured grant

In RACH-less HO, network provides the beam and the associated preconfigured grant of target cell in UE dedicated RRC signaling.

For satellite switching procedure, since the serving cell does not change, we can consider using the legacy configured grant for this purpose, and UE does not need to release it after satellite switching. For example, network may provide two configured grant configurations associated to the different SSBs. When UE switches to the target satellite, and UE detect a good SSB#1 from the target satellite, UE can select the configured grant associated with SSB#1 for 1st UL transmission.

**Proposal 8: For RACH-less satellite switching, network may indicate the beam info for the dynamic grant reception in target satellite in SIB19, and UE starts monitoring the dynamic UL grant via the indicated beam after performing DL sync in the target satellite.**

#### **Question B-8: Do you agree with the proposal 8?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | If the serving and target cells are configured in the same way (same SSB frequency), we do not see a need for further indications. In addition, the transmission beam can be indicated in DCI providing the dynamic UL grant just like in legacy. |
| Samsung | No | Agree with Ericsson, no need of separate CG or DG for 1st UL transmission because there is no first UL transmission for PCI unchanged switch. UE simply follow serving cell configuration and applies the dedicated resource for normal DL/UL transmission. So no additional beam indication is needed. |
| CATT | No | P8 above is per UE configuration, which does not fit the motivation of unchanged PCI to save signaling overhead.  On the other hand, we assume the beam coverage can be unchanged after satellite switch by NW implementation. So the activated TCI state for UE is unchanged. |
| vivo | No | See our reply to Question B-5. |
| Qualcomm | No | This is PCI unchanged case, i.e., same cell, same current ressources are available for UE to use. |
| Lenovo | No |  |
| ZTE | No | Unchanged PCI with RACH skipped is different from RACH-less HO, there is no need to transmit RRCRecofigurationComplete message and no need to pre-allocated UL grant for UE in this case. UE only needs to reacquire SIB19 to do precompensation and re-sync to serving cell if configured by NW, while the rest is the same as staying in connected mode for the same serving cell. |

**Proposal 9: For RACH-less satellite switching procedure, network may provide the configured grant and associated to beam info via RRC dedicated signaling, and UE selects the configured grant based on the detected SSB from the target satellite.**

#### **Question B-9: Do you agree with the proposal 9?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | Same reasoning as in B-5 |
| Samsung | No | Agree with Ericsson, no need of separate CG or DG for 1st UL transmission because there is no first UL transmission for PCI unchanged switch. UE simply follow serving cell configuration and applies the dedicated resource for normal DL/UL transmission. So no additional CG is needed. |
| CATT | No | P9 above is per UE configuration, which does not fit the motivation of unchanged PCI to save signaling overhead. And the CG configured via source satellite can be used directly. |
| vivo | No | See our reply to Question B-5. |
| Qualcomm | No |  |
| Lenovo | No |  |
| ZTE | No | See comments for B-8 |

* Fallback to RACH-based satellite switching

In NTN RACH-less HO, if the RSRP value of the beam associated for the 1st UL grant is lower than a threshold, UE will fall back to RACH-based HO.

The fallback design is also applicable for the RACH-less satellite switching. If no beam associated to the UL grant in target satellite has good quality, UE cannot acquire the valid UL grant for the 1st UL transmission, and UE has to fallback to RACH in order to complete the satellite switching procedure.

**Proposal 10: For RACH-less satellite switching procedure, UE fallbacks to RACH-based satellite switching procedure if the beam associated to the UL grant in target satellite has RSRP value lower than a threshold.**

#### **Question B-10: Do you agree with the proposal 10?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | This procedure is not L3 RACH-less, hence network will not provide a dedicated configuration (e.g., RSRP threshold. It is up to UE implementation. Besides, there is no RSRP threshold and fallback to RACH based on the normal CG based UL transmission in RRC\_CONNECTED mode. Thus, there is no need for a new behavior if UE can follow normal UL transmission after the switch with unchanged PCI. |
| Samsung | No | Agree with Ericsson, no need of separate CG or DG for 1st UL transmission because there is no first UL transmission for PCI unchanged switch. UE simply follow serving cell configuration and applies the dedicated resource for normal DL/UL transmission. So no beam selection or fallback is needed. |
| CATT | No | Similar to our comments in QB-8, after satellite switch, the serving beam of the UE is unchanged. |
| vivo | No | See our reply to Question B-5. |
| Lenovo | No |  |
| ZTE | No | See comments for B-8 |
|  |  |  |

* TA value for the 1st UL transmission

In NTN RACH-less HO, network can set the Nta value to 0 or same as source satellite in the RACH-less HO command to UE.

For RACH-less satellite switching, network can also provide the same information based on the deployment (e.g. set Nta as 0 if source and target satellite are not collocated together). Since it’s based on the deployment, it can be regarded as cell specific info and provided in SIB19.

**Proposal 11: For RACH-less satellite switching procedure, network can set Nta value to 0 or same as source in SIB19.**

#### **Question B-11: Do you agree with the proposal 11?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Yes (see comment) | We understand that rapporteurs want to say that UE independently sets NTA to 0. For unchanged PCI, there’s no case where source and target belong to the same satellite. |
| Samsung | Yes |  |
| CATT | Yes |  |
| vivo | No | See our reply to Question B-5. |
| Qualcomm | Yes | As satellite has changed and TA has changed. But even for RACH-based, this should be applicable. |
| Lenovo | Yes |  |
|  |  |  |

* The message in the 1st UL transmission towards target satellite

In NR RACH-less HO and LTE RACH-less mobility, after UE switches to the target cell, UE will transmit the RRCReconfigurationComplete message to network.

For satellite switching procedure, it’s not L3 involved mobility, and the serving cell configuration doesnot changes. Therefore, it’s no need to transmit RRCReconfigurationComplete message, and UE can directly perform the data transmission/reception in target satellite.

**Proposal 12: For RACH-less satellite switching procedure, UE resumes the UE dedicated transmission/reception via the 1st UL grant towards to target satellite.**

#### **Question B-12: Do you agree with the proposal 12?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Yes |  |
| Samsung | Yes with comment | There is no 1st UL grant, it’s just the same UE dedicated DL/UL resources for the same serving cell. |
| CATT | Yes |  |
| vivo | No | See our reply to Question B-5. |
| Qualcomm |  | Not clear what is the 1st UL grant.  We think whether be it RACH or PUCCH, UE has to send some UL signal to complete the switch. |
| Lenovo | Yes |  |
|  |  |  |

### 2.2.3. Coexistence with L3 mobility scheme

After network enables the satellite switching procedure, network can also decide trigger UE perform HO to other cell. And UE should follow the HO command and initiate HO procedure immediately.

**Proposal 13: After satellite switching scheme is enabled, if UE receives the HO command before the switching period or switching point, UE will initiate the HO procedure immediately.**

#### **Question B-13: Do you agree with the proposal 13?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Yes | As a general rule, dedicated configuration takes precedence. |
| Samsung | Yes |  |
| CATT | Yes |  |
| vivo | Yes | Agree with Ericsson. |
| Qualcomm | Yes |  |
| Lenovo | Yes |  |
| ZTE | Yes |  |

For CHO scheme, since it is enabled in advanced, network may also possibly enable both CHO and satellite switching procedure at the same time. And in UE side, UE can just follow the condition evaluation to initiate the corresponding scheme, e.g. UE can initiate CHO when CHO condition is met, and initiate satellite switching when the satellite switching time is arrived. When both conditions are met, it could up to UE implementation to choose either one.

**Proposal 14: Both CHO and satellite switching procedure can be configured simultaneously.**

#### **Question B-14: Do you agree with the proposal 14?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | Yes |  |
| Samsung | Yes | NW should not configure CHO and PCI unchanged satellite switch for the same PCI, CHO should be for a different PCI. But this is up to NW implementation. |
| CATT | Yes | For the UE at cell edge, there may be requirement to configure location-based CHO to enhance its mobility. |
| vivo | Yes | As satellite switching is cell-specific, then the NW can configure CHO for a given UE to overwrite the satellite switching behavior. |
| Qualcomm | Yes |  |
| Lenovo | Yes |  |
| ZTE | Yes | Since NW doesn’t know when UE will execute CHO when providing UE with CHO configuration, it is possible that CHO and unchanged PCI can be enabled at the same time. If so, UE is expected to perform the procedure based on which condition fulfills first.  Furthermore, there is no restriction in current specs that the PCI of candidate CHO cell shall always be different from current serving, i.e., it is allowed in specs to configure CHO candidate cell with the same PCI as current serving cell. To avoid complexity, we understand this configuration is still consider as a l3 procedure, which is similar to intra-cell HO. |

**Proposal 15: When both CHO and satellite switching conditions are met, it's up to UE implementation to choose either one.**

#### **Question B-15: Do you agree with the proposal 15?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Ericsson | No | UE shall follow dedicated configuration. |
| Samsung | No | NW should not configure CHO and PCI unchanged satellite switch for the same PCI. |
| CATT | See comments | We prefer to perform the procedure whose condition is met firstly. Upon disconnecting to source satellite, when the UE switches to target satellite, the UE stops evaluating the conditions of CHO. |
| vivo | N | Following the logic of the current spec, it is generally dedicated signaling override broadcast signaling, so we think UE will choose to perform CHO procedure when both CHO and satellite switching conditions are met. |
| Qualcomm | See comments | Unless CHO is released or cancelled, UE should keep following the existing procedure. The network should not configure CHO for the same PCI. |
| Lenovo | No | Dedicated signaling will override the broadcast signaling. |
| ZTE | See comments | Same view as CATT. UE is expected to perform the procedure based on which condition fulfills first. |

# **3 Summary**

***Rapporteur Summary:***

# **4 Conclusion**

**List of proposals for agreement (if any):**

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

# 5 References

1. RAN2-123bis - NR-NTN-IoT-NTN (Sergio)\_EOM
2. R2-2311319-[AT123bis][307][NR-NTN Enh] Unchanged PCI (Apple)

# 6 Contact information

|  |  |
| --- | --- |
| Company | Delegate contact |
| Samsung | [shiyang.leng@samsung.com](mailto:shiyang.leng@samsung.com) |
| vivo | yitao.mo@vivo.com |
| Lenovo | xumin13@lenovo.com |
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# 7 RAN2 agreements on unchanged PCI

|  |
| --- |
| RAN2#122 Agreements   * t-Service in SIB19 can also be interpreted by Rel-18 UE in Connected mode to know that a satellite change or feeder link change happens * In hard switch unchanged PCI scenario (i.e. no handover), the UE needs to know the time the UE attempts to re-synchronize. (FFS whether a new “t-Start” / a t-gap is needed or whether t-Service can be reused (i.e. no other IE) if the gap is very short/zero). |
| RAN2#123 Agreements   * An explicit indication will be introduced to enable the unchanged PCI switch * The unchanged PCI mechanism can be applied to the case where the coverage gap is zero or negligible (where there is no need to introduce t-gap or t-start). FFS whether we need to support scenarios that require the introduction of t-gap or t-start * PCI unchanged procedure can be performed without performing RACH * In the unchanged PCI case, the UE considers UL synchronization timer expired at t-Service (current cell stop time) to stop any UL operation. FFS on timeAlignmentTimer handling. * In the unchanged PCI case, for RACH-based solution, the UE may trigger RACH immediately after DL synchronizing with the new satellite * The UE specific Koffset, if configured, is not used after t-Service and the UE uses the cell specifc Koffset until the UE receives new differential Koffset MAC CE. |
| RAN2#123bis Agreements   * We don’t consider the impact on Rel-17 UEs behavior (or Rel-18 UEs not supporting unchanged PCI) when defining the Rel-18 unchanged PCI solution * Network provides the sync information of target satellite in advance to UE before satellite switching, via broadcast signalling * RAN2 confirms satellite switching with unchanged PCI is only applicable on quasi-earth fixed system * Only 1 target satellite information (i.e. NTN-config) of serving cell is provided in SIB19. FFS on exact signalling * SMTC configuration of target satellite needs further discussion:   + FFS on whether and how to provide the SMTC configuration of target satellite.   + FFS on how to handle the SMTC adjustment. * We support soft satellite switching in Rel-18 * There will be an indication (FFS if explicit or implicit) whether hard switch or soft switch is used. * At least soft satellite switching, network provides SSB information of target satellite to UE. FFS on the details: options include e.g. indicating a time offset/information or indicating a different SSB index for the target satellite (FFS for Hard satellite switch) * In soft satellite switching, UE can start synchronizing with target satellite before T-service of source satellite. * We introduce a T-start which indicates the earliest occasion when the UE can start synchronizing with target satellite (actual signalling is FFS). In soft switch scenario, T-start of target satellite is earlier than T-service of source satellite (FFS if T-start is also used for hard satellite switch) * For soft satellite switching, the exact time when the UE starts synchronizing with target satellite (between T-start and T-service) is up to UE implementation. * UE is not required to connect to source satellite when the UE switches to target satellite. |