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.



* 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.



* 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} |
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**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.*

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| **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. |
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#### **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. |
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#### **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. |
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### **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. |
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**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. |
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**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. |
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**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. |
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**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. |
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**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?**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | No | Rely on legacy PHR triggering is sufficient. |
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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. |
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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. |
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#### **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. |
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### 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.  |
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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?**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | No | Same reasoning as in B-5. |
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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?**

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| **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. |
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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?**

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| **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. |
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**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?**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | No | Same reasoning as in B-5 |
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* 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?**

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| **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. |
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* 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?**

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| **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. |
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* 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?**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | Yes |  |
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### 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?**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | Yes | As a general rule, dedicated configuration takes precedence. |
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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?**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | Yes |  |
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**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?**

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| **Company** | **Y/N** | **Comments** |
| Ericsson | No | UE shall follow dedicated configuration. |
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# **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

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| Company | Delegate contact |
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# 7 RAN2 agreements on unchanged PCI

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| 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).
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| 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.
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| 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.
 |