3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023
Agenda Item: 5
Document for: Discussion

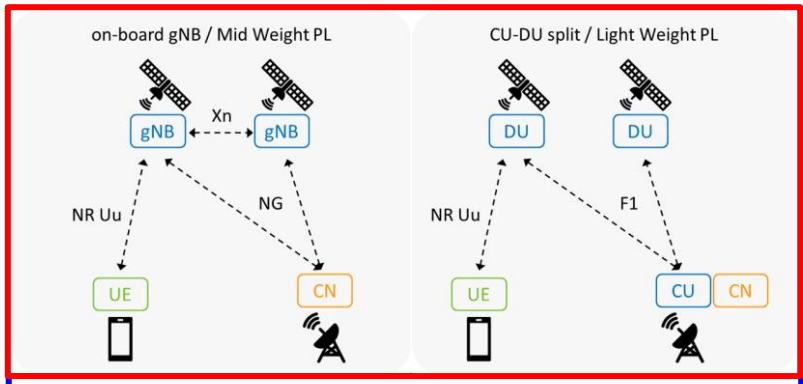
RWS-230253

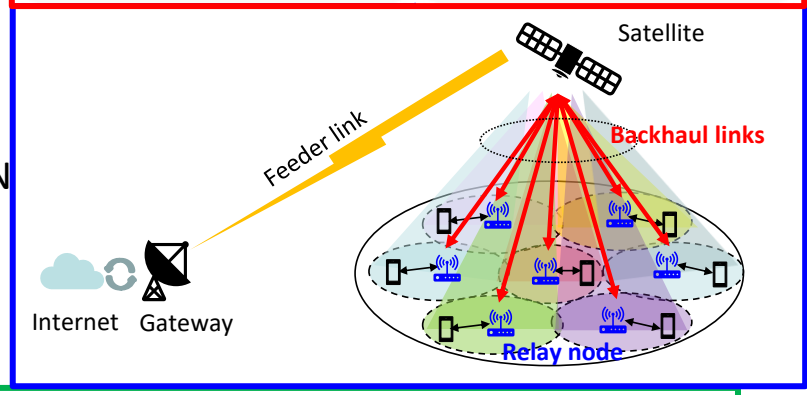
Further enhancements on NR NTN

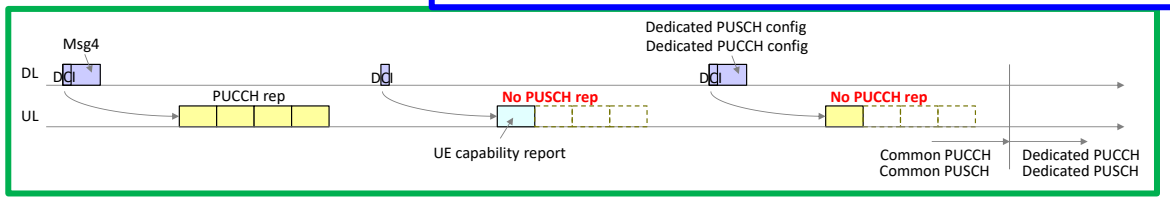
NTT DOCOMO, INC.

Overview

- Rel-17 NR NTN
  - Initial spec for NR NTN
    - » E.g., NTN-specific synchronization, timing-related enhancements in lower/higher layers, HARQ-related enhancements, NTN-specific mobility support
    - » Transparent payload
- Rel-18 NR NTN
  - Enhancements for three aspects
    - » 1. Coverage of handheld UEs
    - » 2. UE location verification by NW side
    - » 3. Better mobility/service continuity
- Rel-19 NR NTN
  - The following three topics should be included
    - » A. **Regenerative payload support**: more flexible NW, shorter RTT, towards meshed NTN
    - » B. **UL data rate enhancement**: support 1 Mbps or more for handheld UEs
    - » C. **Coverage enhancement**: at least leftovers for handheld UE support in NR NTN
    - » Note: in addition, HAPS-specific discussion as mentioned in RWS-230262 is also an important topic for R19

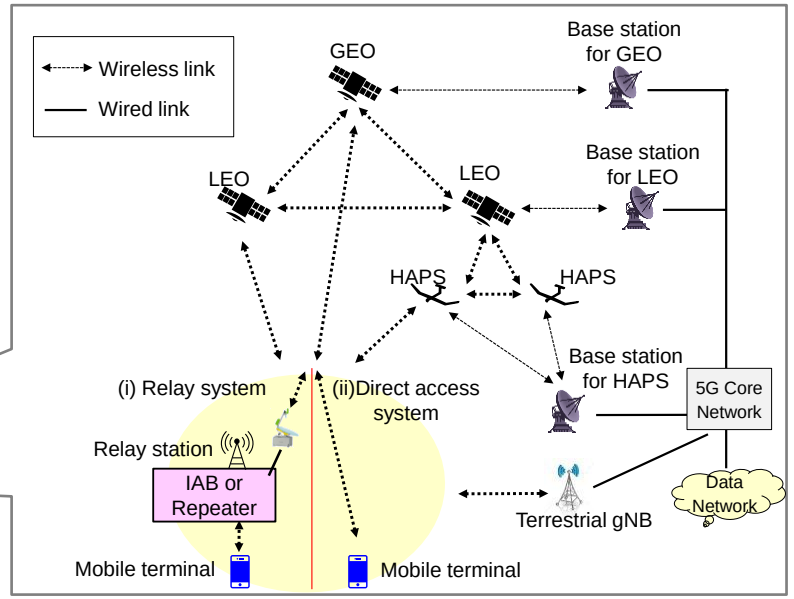




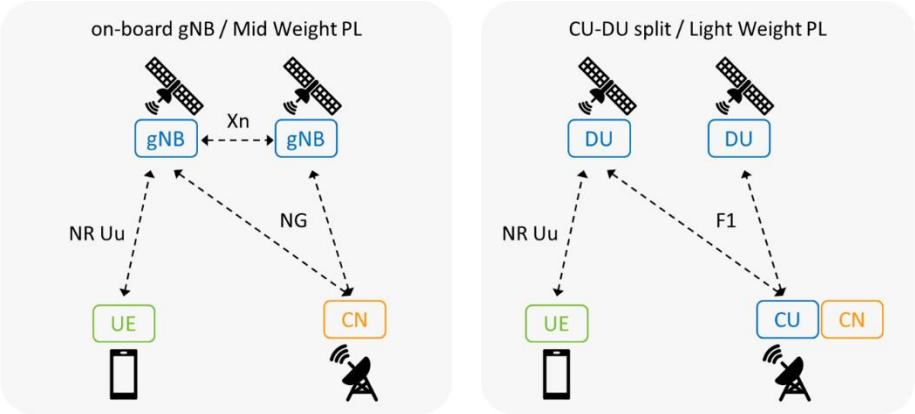


Regenerative payload support (1/2)

- Background (Justification)
  - Study on introduction of NTN was conducted in Release 16. Both transparent and regenerative payload were in scope at that time, but in later releases (Rel-17/18) only transparent payload was taken in consideration.
  - Support of regenerative payload enables more flexible NTN as well as shorter round-trip time for L1/MAC interaction.
    - » Steady step to realize meshed NTN (i.e., NTN with inter-satellite/HAPS links) in future releases.
  - Scope of item: including LEO/GEO/HAPS scenarios, both on-board gNB (with ISL) and CU-DU split (without ISL) implementations.
  - TR 38.821 clarified potential normative works to support, which is a good starting point.



Future (later releases) realization of meshed-NTN



Scope of regenerative payload implementations in Rel-16 study

Regenerative payload support (2/2)

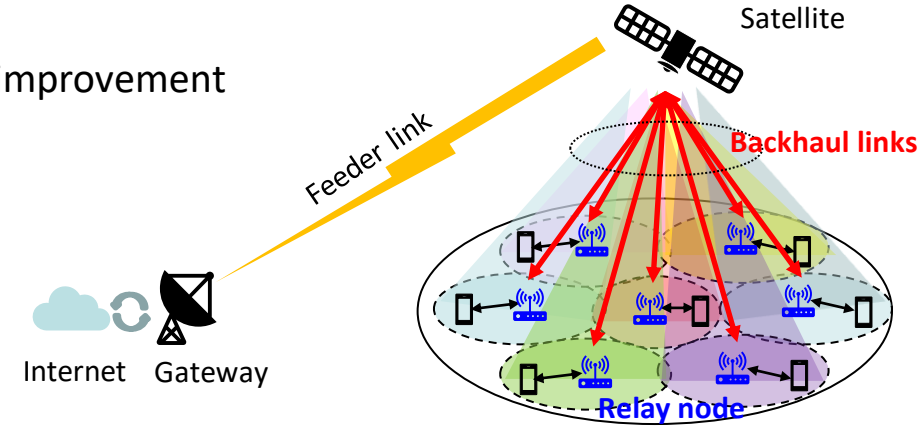
- Proposal (Objective)

This topic aims to specify the enhancements identified for regenerative payload architecture of NR NTN (non-terrestrial networks) especially CU-DU split and on-board gNB architecture regarding the following aspects:

- Specify an enhancements for the F1 interface (RAN3)
  - » Signaling enhancements for UP packet buffering considering RTT.
- Analyze impacts on F1/Xn/NG interfaces, if necessary (RAN3)
  - » Suspending F1 interface in case of feeder link switch over in CU-DU split architecture (described in clause 8.7.2.3, TR 38.821).
  - » Suspending NG interface in case of feeder link switch over in on-board gNB architecture (described in clause 8.7.2.2, TR 38.821).
  - » Signaling enhancements for frequent Xn setups in case of feeder link switch over in on-board gNB architecture, or in case of SRI (satellite radio interface) switch over in on-board gNB architecture with ISLs (inter satellite links) (described in clause 8.4.3.4, TR 38.821).

UL data rate improvement via relay node

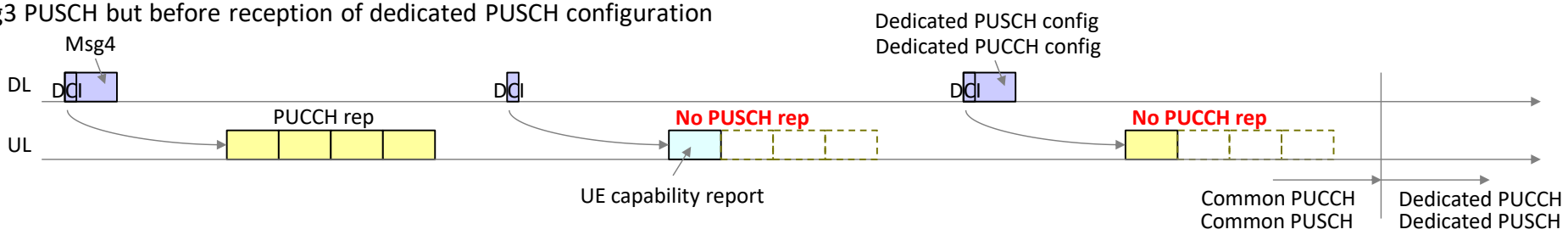
- Background (Justification)
  - In Release 18, coverage enhancement is studied/specified for handheld UE in NTN with extremely low data rate requirement of **several kbps**
    - » For support of such a low data rate, a number of UL repetitions are essential for any handheld UE, which is inefficient and impractical
  - Much larger data rate as **1 Mbps** or more would be required for market expansion of NTN
    - » Similar user experience as in TN is desirable
  - Satellite access through relay nodes on the ground is beneficial for the data rate improvement
    - » For relay nodes, IAB/NCR are the candidates
    - » Such an architecture is included in SA spec on satellite access (TR 22.865)



- Proposal (Objective)
  - Study and (if feasible/necessary) specify NR NTN via relay node on the ground
    - » Study NR NTN via IAB on the ground
      - – Timing aspects of IAB node, e.g., “case1” timing, “case7” timing, misalignment between MT/DU, F1 interface enhancement to deal with higher RTT (similar to regenerative payload)
    - » Study NR NTN via NCR on the ground
      - – Timing aspects of NCR-related indication
      - – Usage of NTN+NCR, e.g., when UE can access NTN via relay node, how UE differentiates R17/18 NTN (direct access) and NTN via relay node, etc.

Coverage enhancement

- UL coverage enhancement
  - Background (Justification)
    - » In R18 NR NTN, repetition for Msg4 HARQ-ACK and NTN-specific DMRS bundling for PUSCH are to be specified. Besides, PRACH repetition is to be specified in R18 CovEnh WI
    - » However, two UL transmissions are still insfficient for handheld UE in NTN due to non-support of repetition. The reason seems to be that simply the problem was missed in study/work. Although they are under discussion in R18 NR NTN and in R18 TEI, but may not be specified
      - – PUCCH transmission after Msg4 HARQ-ACK but before reception of dedicated PUCCH configuration
      - – PUSCH transmission after Msg3 PUSCH but before reception of dedicated PUSCH configuration

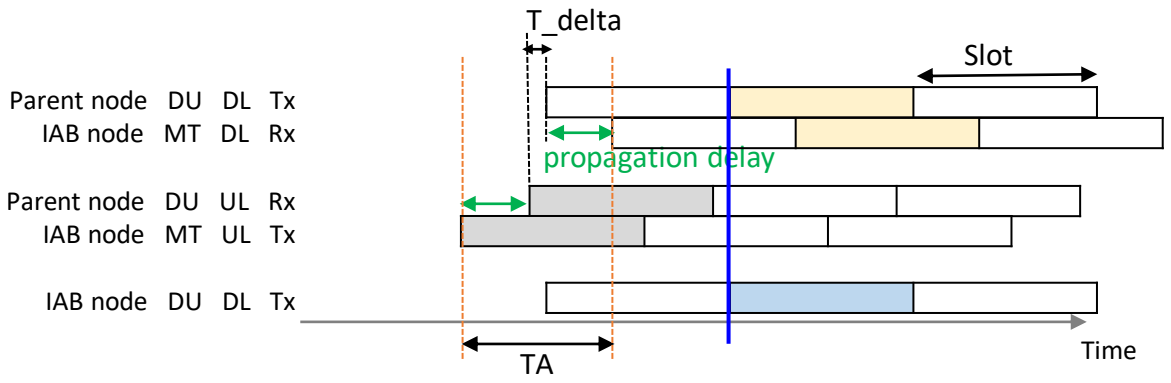


  - Proposal (Objective)
    - » (If not supported in R18,) specify repetition for PUCCH after Msg4 HARQ-ACK and before reception of dedicated PUCCH config
    - » (If not supported in R18,) specify repetition for PUSCH after Msg3 PUSCH and before reception of dedicated PUSCH config
      - – Note: This may be handled in TN coverage enhancement WI as mentioned in RWS-230258

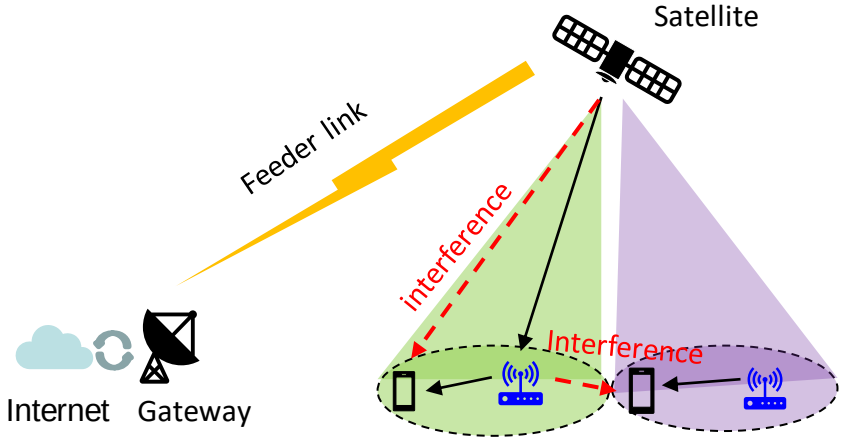
- DL coverage enhancement
  - View
    - » In R18, it was argued that DL coverage is also insufficient due to PFD limitation or satellite capability for multiple-beam operation. The necessity was not common understanding and hence the topic was finally dropped. It can be assumed that this topic is discussed again for R19. From our perspecitve, DL coverage enh can be considered as one of R19 topics if there is really problem, but at least we should have study phase to clarify the necessity first. After that, study phase to identify bottleneck channels and work phase to decide specification impact may be considerable

Appendix – details on UL data rate improvement

- NR NTN via IAB on the ground
  - Example 1: “case-1” timing alignment
    - » In TN, DL timing is aligned across gNBs/IAB nodes, so that interference between DL signals from gNBs/IAB nodes can be alleviated.
    - » In Rel-16/17 IAB, an IAB node sets its DL Tx timing same as DL Tx timing of its parent node using TA and T_delta, where T_delta accounts for the gap between DL Tx and UL Rx timing at parent node.
    - » In NTN via IAB on the ground, DL timing needs to be aligned across IAB nodes on the ground. Interference alleviation at UE side between DL signals from gNB and DL signals from IAB-DU needs to be considered as well. How to determine DL timing of IAB-DU for IAB nodes connecting to NTN needs to be studied.



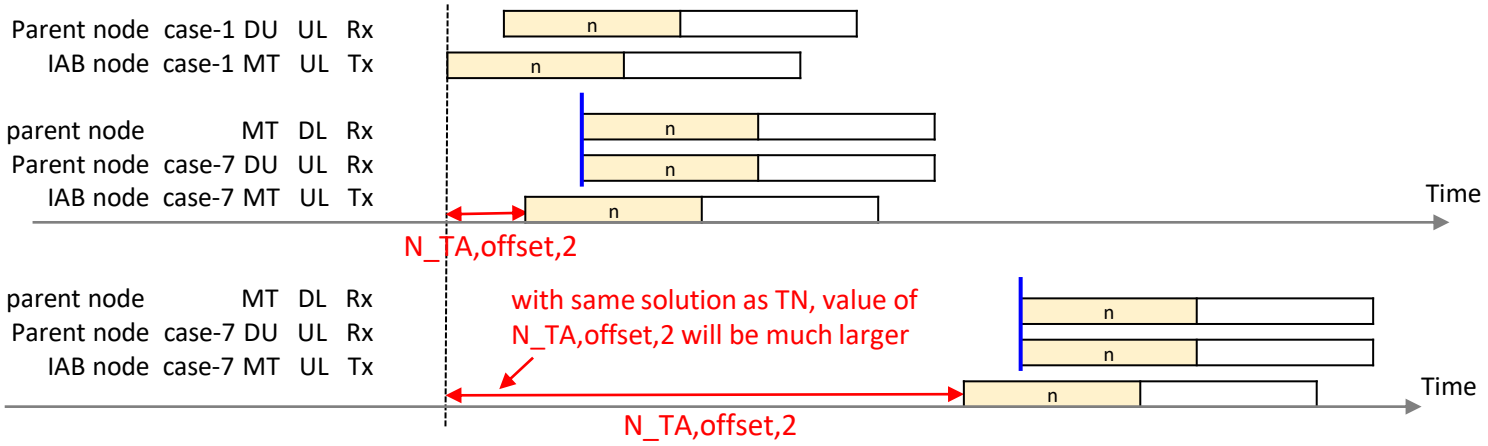
Example of case-1 timing alignment in TN



Example of interference between DL signals from gNB and DL signals from IAB nodes

Appendix – details on UL data rate improvement

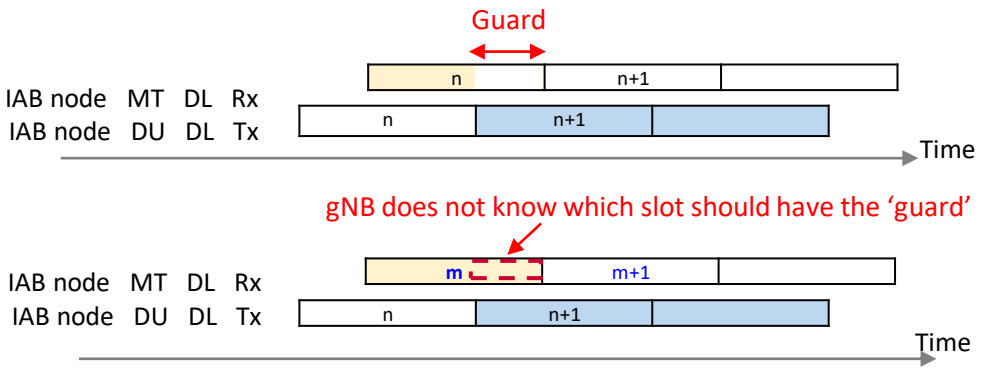
- NR NTN via IAB on the ground
  - Example 2: “case-7” timing alignment
    - » In Rel-17 IAB, IAB node determines its UL transmission timing as TA + N_TA,offset,2 ·Tc , where N_TA,offset,2 approximately accounts for the propagation delay between its parent node and grand-parent node.
    - » In NTN, the propagation delay can be much larger than TN. Case-7 timing alignment for IAB nodes connecting to NTN needs to be studied.



Example of case-7 timing alignment
(upper: TN, lower: NTN)

Appendix – details on UL data rate improvement

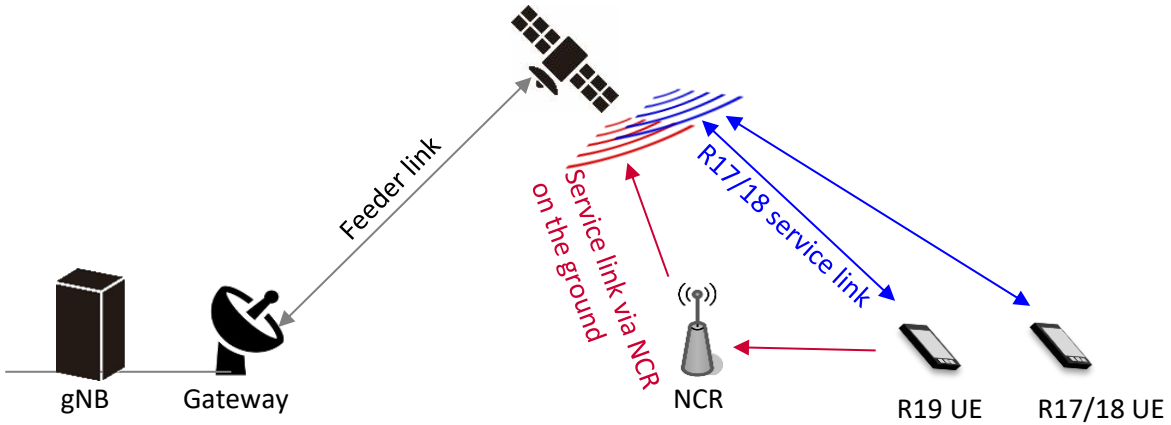
- NR NTN via IAB on the ground
  - Example 3: MT/DU timing misalignment
    - » In Rel-16/17 IAB, guard symbols can be reported so that parent node is aware of misalignment of MT Tx/Rx and DU Tx/Rx timing at IAB node.
    - » In NTN, the misalignment between MT Tx/Rx and DU Tx/Rx timing can be much larger than TN. Report of MT/DU timing misalignment for IAB nodes connecting to NTN needs to be studied.

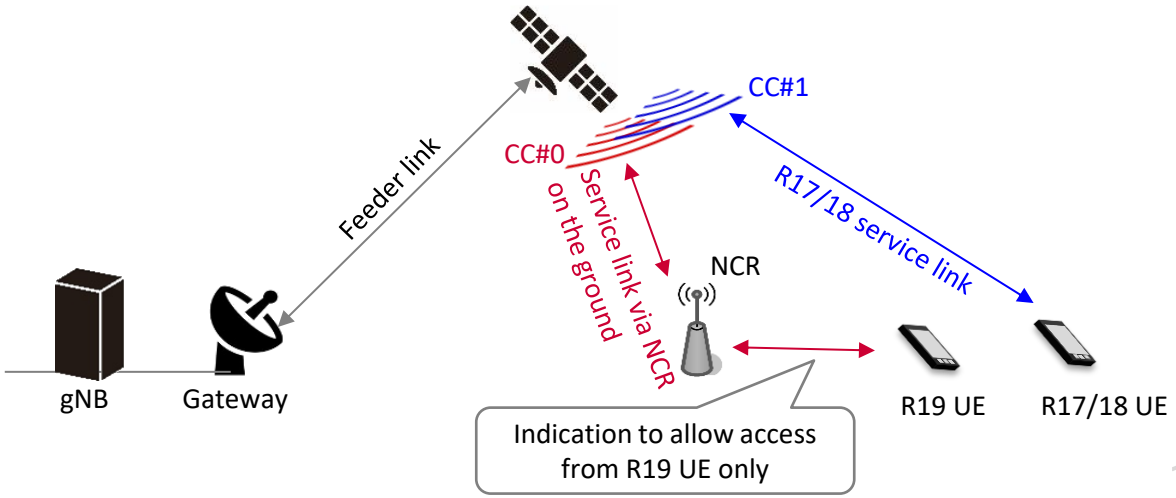


Example of MT/DU timing misalignment
(upper: TN, lower: NTN)

Appendix – details on UL data rate improvement

- NR NTN via NCR on the ground
  - Example 1: Timing aspects of NCR-related indication
    - » In R18 NCR, resource allocation / beam indication for access link via MAC-CE or DCI format 2_8 includes timing indication
    - » For NTN, additional offset by using K_offset or K_mac would be required for such a NCR-related timing indication
  - Example 2: Enhancement of UE-specific TA
    - » When NTN service link is via NCR, the existing UE-specific TA mechanism does now work well
    - » Modified determination mechanism for TA corresponding to NTN service link via NCR will be necessary
  - Example 3: Usage of NTN via NCR on the ground
    - » From UE perspective, NCR is transparent node. Meanwhile, TA calculation will be different as mentioned in Example 2, and also existence of legacy UEs shall be considered. Some rule/restriction to use NTN via NCR on the ground will be inevitable
      - – Possibility 1: UE has a connection within a cell based on R17/18 NR NTN, and NTN via NCR on the ground is used as a kind of SUL additionally
      - – Possibility 2: Band/cell for legacy UE and band/cell for R19 UE are separately configured and indication to inform UE of applying R19 sync as Example 2, without NBC issue





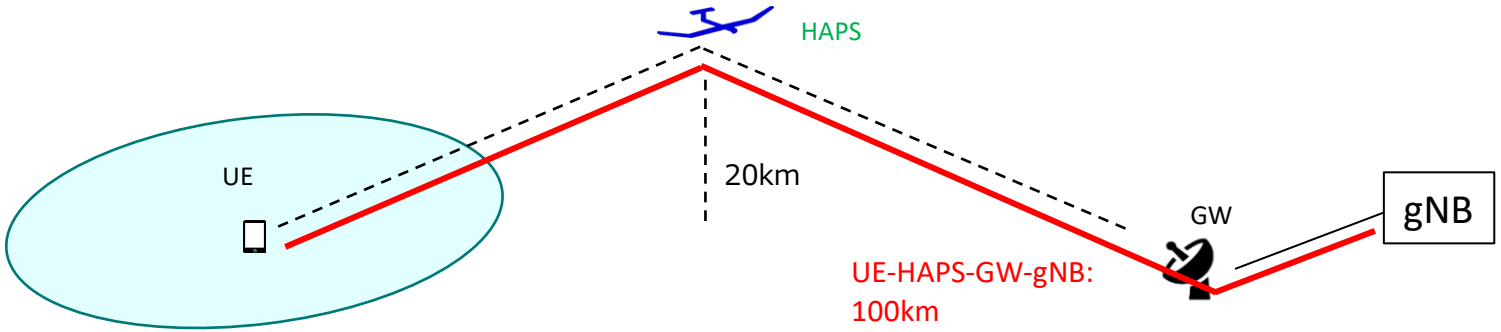
Appendix – HAPS-specific discussion in RWS-230262

- Views on Rel-18
  - HAPS is expected as a means of expanding coverage
  - According to the current TS 38.104, NR operating band n1 can be applied for HAPS operation as below

> 5.2 Operating bands (TS 38.104 V18.1.0)
>
> NR is designed to operate in the operating bands defined in table 5.2-1 and 5.2-2.
>
> **NR operating band n1, which is defined in Table 5.2-1, can be applied for HAPS operation.**

  - From operator's point of view, it is important to increase choice for HAPS bands not only FDD but also TDD e.g., Band 34/n34 based on the need taking the outcome of WRC-23 below into account

- Related ITU-R discussions
  - Only 2GHz is allowed in the current RR
  - Expansion of frequency ranges for HIBS will be discussed in agenda item 1.4 in WRC-23



Appendix – HAPS-specific discussion in RWS-230262

- RAN4 spec impact especially for TDD band
  - Although the RAN1 spec (TS 38.211) already specified PRACH format 1 which can cover propagation distance of UE-HAPS-GW-gNB (about 100 km), the current RAN4 BS spec (TS 38.104) does not define it for FR1. Also, 3ms UL duration for PRACH format 1 needs to be covered by additional TDD patten
  - Since the existing TDD patterns specified in A.1.2 of 38.101-4 cannot support 100 km coverage due to lack of guard symbols, additional TDD pattern with more guard symbols will be necessary

1. PRACH format 1 for FR1

8.4.2 PRACH detection requirements

8.4.2.1 General

The probability of detection is the conditional probability of correct detection of the preamble when the signal is present. There are several error cases – detecting different preamble than the one that was sent, not detecting a preamble at all or correct preamble detection but with the wrong timing estimation. For AWGN, TDLC300-100 and TDLA30-10, a timing estimation error occurs if the estimation error of the timing of the strongest path is larger than the time error tolerance given in Table 8.4.2.1-1.

The performance requirements for high speed train (table 8.4.23-1 to 8.4.2.3-4) are optional.

Table 8.4.2.1-1: Time error tolerance for AWGN, TDLC300-100 and TDLA30-10

PRACH preamble	PRACH SCS (kHz)	Time error tolerance		
		AWGN	TDLC300-100	TDLA30-10
0	1.25	1.04 us	2.55 us	N/A
A1, A2, A3, B4,	15	0.52 us	2.03 us	0.67 us
C0, C2	30	0.26 us	1.77 us	0.41 us

The test preambles for normal mode are listed in table A.6-1 and the test parameter *msg1-FrequencyStart* is set to 0. The test preambles for high speed train restricted set type A are listed in A.6-3, the test preambles for high speed train restricted set type B are listed in A.6-4, and the test preambles for high speed train short formats are listed in A.6-5. The test parameter *msg1-FrequencyStart* for high speed train is set to 0.

The test preambles for PRACH with LRA=1151 and LRA=571 are listed in table A.6-6.

2. Additional TDD pattern

A.1.2 TDD UL-DL configurations for FR1

TDD UL-DL configurations for performance requirements are provided in Tables A.1.2-1, A.1.2-2, and A.1.2-3.

Table A.1.2-1: TDD UL-DL configuration for SCS 15 kHz

Parameter		Unit	UL-DL pattern FR1.15-1
TDD Slot Configuration pattern (Note 1)			DDDSU
Special Slot Configuration (Note 2)			10D+2G+2U
referenceSubcarrierSpacing		kHz	15
pattern1	*dl-UL-TransmissionPeriodicity*	ms	5
	nrofDownlinkSlots		3
	nrofDownlinkSymbols		10
	nrofUplinkSlot		1
	nrofUplinkSymbols		2
The number of slots between PDSCH and corresponding HARQ-ACK information (Note 3)			4 if mod(i,5) = 0 3 if mod(i,5) = 1 2 if mod(i,5) = 2 6 if mod(i,5) = 3

Note 1: D denotes a slot with all DL symbols; S denotes a slot with a mix of DL, UL and guard symbols; U denotes a slot with all UL symbols. The field is for information.
Note 2: D, G, U denote DL, guard and UL symbols, respectively. The field is for information.
Note 3: i is the slot index per frame; i = {0,…,9}.

NTT docomo