Non-Terrestrial Network Rel-17 Work Item Description

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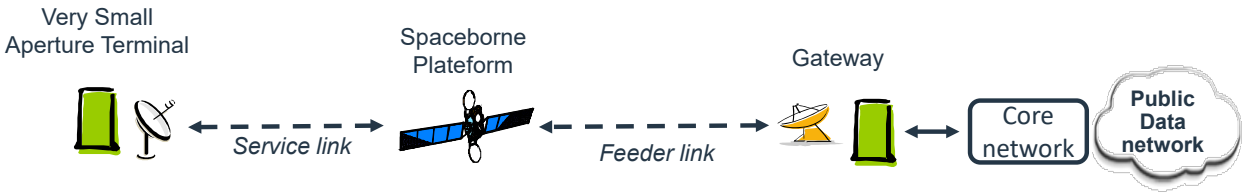
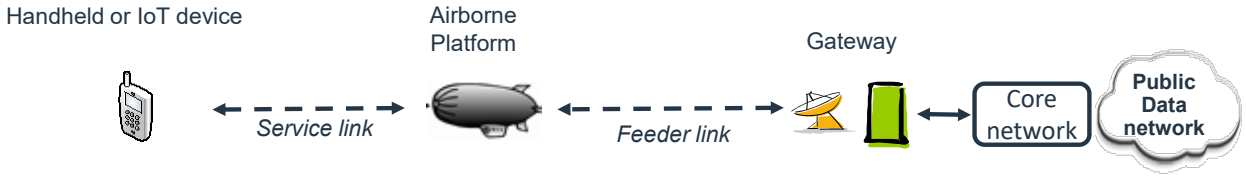
What is NTN?

NTN is networks, or segments of networks, using an airborne or spaceborne vehicle for transmission [3]



Low Earth Orbiting (LEO) satellites,
Medium Earth Orbiting (MEO) satellites,
Geostationary Earth Orbiting (GEO) satellites , …



High Altitude Platforms (HAPs)
Unmanned Aircraft Systems (UAS), …

Timeline

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Scenario Descriptions
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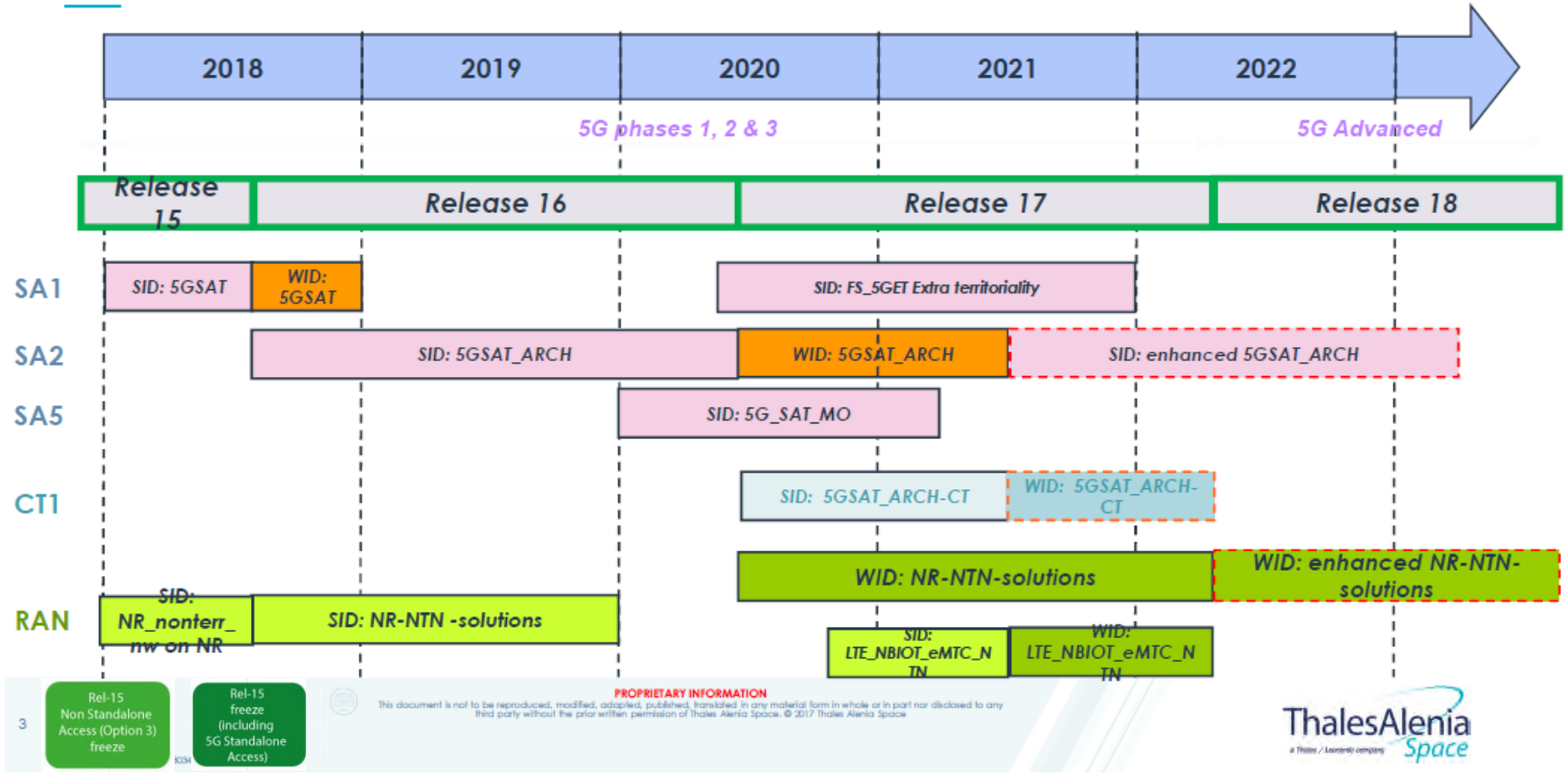
3GPP NTN Timeline

NTN/Satellite Roadmap



RAN#78 RAN#80 RAN#86

Source: Thales, ETRI 6G Sat Wokshop2021
3GPP

3GPP NTN Timeline

NTN/Satellite Standardization Status & Plane

Rel	Item Ref	Lead WG	Title	Doc	Compeltion
15	SI "FS_NR_nonterr_nw on NR"	RAN	Study on New Radio (NR) to support Non Terrestrial Networks (Release 15)	TR 38.811	June 2018
	SI "FS_5GSAT"	SA1	Study on using Satellite Access in 5G; Stage 1 (Release 16)	TR 22.822	June 2018
16	SI "FS_NR_NTN_solutions"	RAN3	Solutions for NR to support non-terrestrial networks (NTN) (Release 16)	TR 38.821	Dec 2019
	WI "5GSAT"	SA1	Service requirements for the 5G system; Stage 1 (Release 16)	CR to TS 22.261	Dec 2018
	SI "FS_5GSAT_ARCH"	SA2	Study on architecture aspects for using satellite access in 5G (Release 16)	TR 23.737	June 2020
	SI "FS_5G_SAT_MO"	SA5	Study on management and orchestration aspects of integrated satellite components in a 5G network	TR 28.808	March 2021
17	**WI "NR_NTN_solutions"**	**RAN2**	**Solutions for NR to support non-terrestrial networks (NTN)**	**CR to TS 38.XXX**	**March 2022**
	WI "5GSAT_ARCH"	**SA2**	**Integration of satellite systems in the 5G architecture**	**CR to TS 23.XXX**	**Sept 2021**
	WI «5GSAT_ARCH-CT»	**CT1**	**Study on PLMN selection for satellite access**	**TR 24.821**	**Sept 2021**
	SI "FS_LTE_NBIOT_eMTC_NTN"	RAN1	Study on Narrow-Band Internet of Things (NB-IoT)/enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN)	TR 36.763	June 2021
	WI "LTE_NBIOT_eMTC_NTN"	**RAN1**	**Solutions for NB-IoT & eMTC to support non-terrestrial networks (NTN)**	**CR to TS 36.XXX**	**March 2022**
18	FS_5GET «Extra territoriality»	SA1	Guidelines for extra-territorial 5G Systems (5GS)	TR 22.961	Dec 2021

CR: Change Requests

Source: Thales, ETRI 6G Sat Wokshop2021

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Service Requirements [3]

TS 22.261 WI "5GSAT"

- TS 22.261 = Service requirements for the 5G system
- Approved at SA#82 (v16.6.0, Dec. 2018)
- Identified use cases for 5G Satellite integration and the corresponding service requirements

Service requirements applicable to satellite access

- Mobile broadband needs in unserved/underserved areas
- Public safety needs
- Maritime, airplane connectivity, and railway communication

Performance Requirements

KPIs for a 5G system with satellite access [TS 22.261]

Table 7.4.2-1: Performance requirements for satellite access

Scenario	Experienced data rate (DL)	Experienced data rate (UL)	Area traffic capacity (DL) (note 1)	Area traffic capacity (UL) (note 1)	Overall user density	Activity factor	UE speed	UE type
Pedestrian (note 2)	[1] Mbit/s	[100] kbit/s	1,5 Mbit/s/km^2	150 kbit/s/km^2	[100]/km^2	[1,5] %	Pedestrian	Handheld
Public safety	[3,5] Mbit/s	[3,5] Mbit/s	TBD	TBD	TBD	N/A	100 km/h	Handheld
Vehicular connectivity (note 3)	50 Mbit/s	25 Mbit/s	TBD	TBD	TBD	50 %	Up to 250 km/h	Vehicle mounted
Airplanes connectivity (note 4)	360 Mbit/s/ plane	180 Mbit/s/ plane	TBD	TBD	TBD	N/A	Up to 1000 km/h	Airplane mounted
Stationary	50 Mbit/s	25 Mbit/s	TBD	TBD	TBD	N/A	Stationary	Building mounted
Narrowband IoT connectivity	[2] kbit/s	[10] kbit/s	8 kbit/s/km^2	40 kbit/s/km^2	[400]/km2	[1] %	[Up to 100 km/h]	IoT

Note 1: Area capacity is averaged over a satellite beam.
Note 2: Data rates based on Extreme long-range coverage target values in clause 6.17.2. User density based on rural area in Table 7.1-1.
Note 3: Based on Table 7.1-1
Note 4: Based on an assumption of 120 users per plane 15/7.5 Mbit/s data rate and 20 % activity factor per user
Note 5: All the values in this table are targeted values and not strict requirements.
Note 6: Performance requirements for all the values in this table should be analyzed independently for each scenario.

Service Requirements

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Two Activities Since RAN#76 [3]

TR 38.811, Study on NR to support NTN

- Studied the channel model for the non-terrestrial networks, to define deployment scenarios, parameters and identify the key potential impacts on NR
- The work led by RAN started at RAN#76 and has been completed at RAN#80

TR 38.821, Solutions for NR to support NTN

- Define and evaluate solutions for the identified key impacts from the first activity
- The work led by RAN3 started at RAN#80 and completed at RAN#86

NG-RAN Architecture [1]-[2]

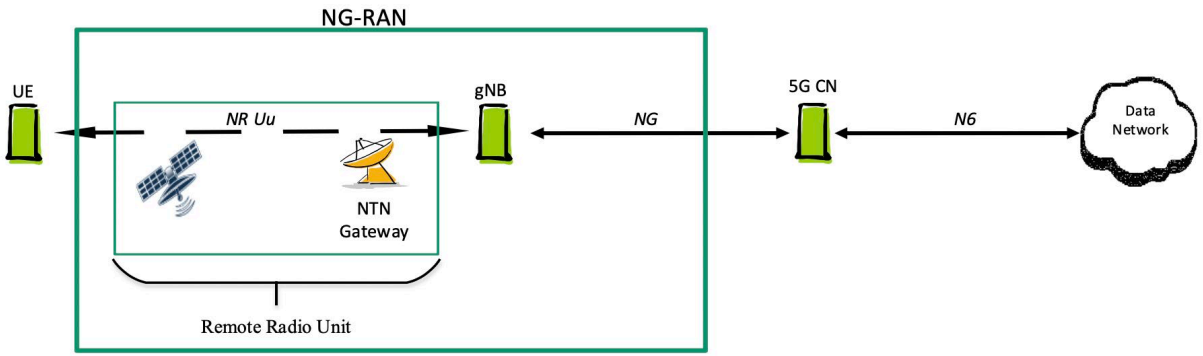
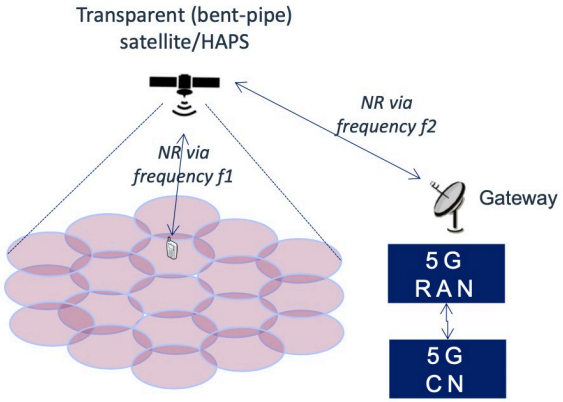


Figure 5.1-1: Networking-RAN architecture with transparent satellite



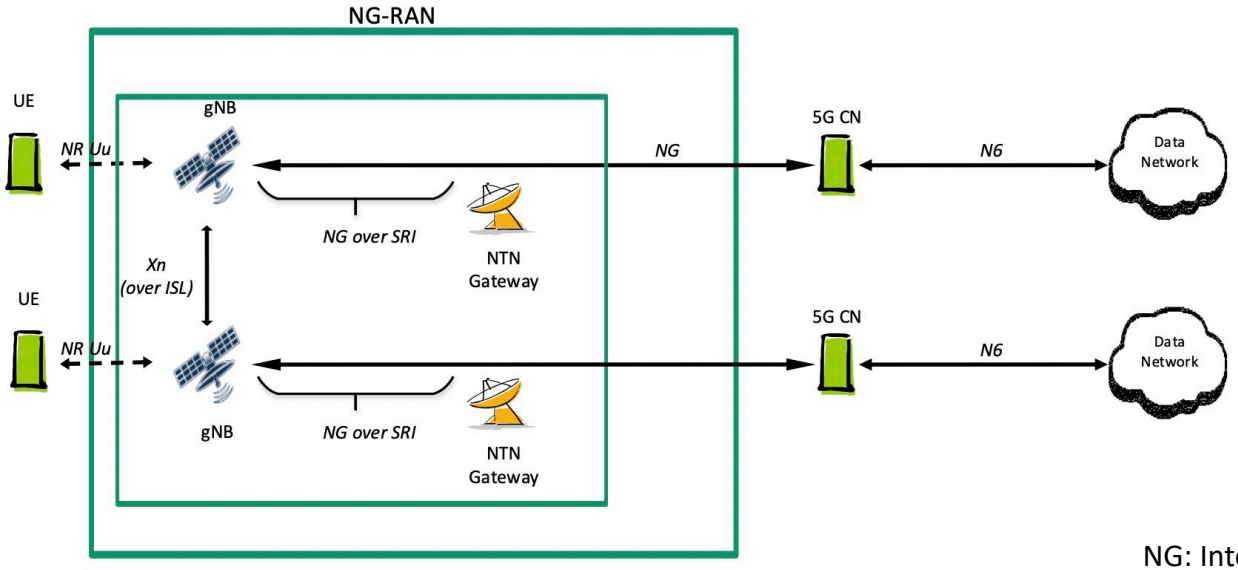
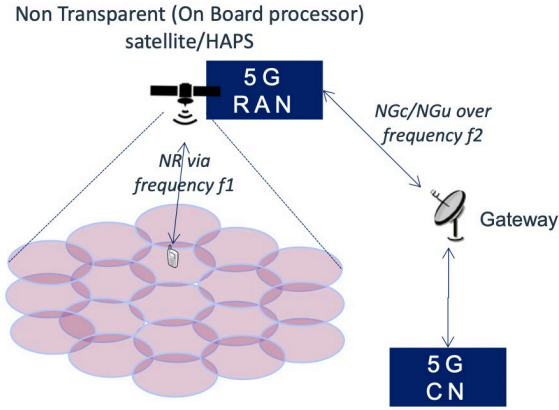


Figure 5.2.1-2: Regenerative satellite with ISL, gNB processed payload



NG: Interface b/w gNB and 5G core network
SRI: Satellite radio interface
Uu: Interface b/w UE-gNB

UE Types for NTN [1]

Table 4.4-1: Typical minimum RF characteristics of UE in satellite and aerial access networks

	Very Small Aperture Terminal (fixed or mounted on moving platforms)	Handheld or IoT devices (3GPP class 3, see [2])
Transmit Power	2 W (33 dBm)	200 mW (23 dBm)
Antenna type	60 cm equivalent aperture diameter (circular polarisation)	Omnidirectional antenna (linear polarisation)
Antenna gain	Tx: 43.2 dBi Rx: 39.7 dB	Tx and Rx: 0 dBi
Noise figure	1.2 dB	9 dB
EIRP	45.75 dBW	-7 dBW
G/T (NOTE 1)	18.5 dB/K	-33.6 dB/K
Polarisation (NOTE 2)	Circular	Linear

Very Small Aperture Terminal

Ka band

Handheld or IoT device

S band

SV Types & Reference Scenarios [2]

Table 4.1-1: Types of NTN platforms

Platforms	Altitude range	Orbit	Typical beam footprint size
Low-Earth Orbit (LEO) satellite	300 – 1500 km	Circular around the earth	100 – 1000 km
Medium-Earth Orbit (MEO) satellite	7000 – 25000 km		100 – 1000 km
Geostationary Earth Orbit (GEO) satellite	35 786 km	notional station keeping position fixed in terms of elevation/azimuth with respect to a given earth point	200 – 3500 km
UAS platform (including HAPS)	8 – 50 km (20 km for HAPS)		5 - 200 km
High Elliptical Orbit (HEO) satellite	400 – 50000 km	Elliptical around the earth	200 – 3500 km

Table 4.2-1: Reference scenarios

	Transparent satellite	**Regenerative satellite**
GEO based non-terrestrial access network	Scenario A	Scenario B
LEO based non-terrestrial access network: steerable beams	Scenario C1	Scenario D1
LEO based non-terrestrial access network: the beams move with the satellite	Scenario C2	Scenario D2

Reference Scenario Parameters (1/2) [2]

Table 4.2-2: Reference scenario parameters

Scenarios	GEO based non-terrestrial access network (Scenario A and B)	LEO based non-terrestrial access network (Scenario C & D)
Orbit type	notional station keeping position fixed in terms of elevation/azimuth with respect to a given earth point	circular orbiting around the earth
Altitude	35,786 km	600 km 1,200 km
Spectrum (service link)	<6 GHz (e.g. 2 GHz) >6 GHz (e.g. DL 20 GHz, UL 30 GHz)	
Max channel bandwidth capability (service link)	30 MHz for band < 6 GHz 1 GHz for band > 6 GHz	
Payload	Scenario A: Transparent (including radio frequency function only) Scenario B: regenerative (including all or part of RAN functions)	Scenario C: Transparent (including radio frequency function only) Scenario D: Regenerative (including all or part of RAN functions)
Inter-Satellite link	No	Scenario C: No Scenario D: Yes/No (Both cases are possible.)
Earth-fixed beams	Yes	Scenario C1: Yes (steerable beams), see note 1 Scenario C2: No (the beams move with the satellite) Scenario D 1: Yes (steerable beams), see note 1 Scenario D 2: No (the beams move with the satellite)
Max beam foot print size (edge to edge) regardless of the elevation angle	3500 km (Note 5)	1000 km

Reference Scenario Parameters (2/2) [2]

Min Elevation angle for both sat-gateway and user equipment	10° for service link and 10° for feeder link	10° for service link and 10° for feeder link
Max distance between satellite and user equipment at min elevation angle	40,581 km	1,932 km (600 km altitude) 3,131 km (1,200 km altitude)
Max Round Trip Delay (propagation delay only)	Scenario A: 541.46 ms (service and feeder links) Scenario B: 270.73 ms (service link only)	Scenario C: (transparent payload: service and feeder links) 25.77 ms (600km) 41.77 ms (1200km) Scenario D: (regenerative payload: service link only) 12.89 ms (600km) 20.89 ms (1200km)
Max differential delay within a cell (Note 6)	10.3 ms	3.12 ms and 3.18 ms for respectively 600km and 1200km
Max Doppler shift (earth fixed user equipment)	0.93 ppm	24 ppm (600km) 21ppm(1200km)
Max Doppler shift variation (earth fixed user equipment)	0.000 045 ppm/s	0.27ppm/s (600km) 0.13ppm/s(1200km)
User equipment motion on the earth	1200 km/h (e.g. aircraft)	500 km/h (e.g. high speed train) Possibly 1200 km/h (e.g. aircraft)
User equipment antenna types	Omnidirectional antenna (linear polarisation), assuming 0 dBi Directive antenna (up to 60 cm equivalent aperture diameter in circular polarisation)	
User equipment Tx power	Omnidirectional antenna: UE power class 3 with up to 200 mW Directive antenna: up to 20 W	
User equipment Noise figure	Omnidirectional antenna: 7 dB Directive antenna: 1.2 dB	
Service link	3GPP defined New Radio	
Feeder link	3GPP or non-3GPP defined Radio interface	3GPP or non-3GPP defined Radio interface

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Scops of Rel-17 WI on NTN [3]

Normative activity on NR-NTN scenarios of:

- Transparent payload based LEO scenario addressing at least 3GPP class 3 UE (handheld) with and without GNSS capability and both Earth fixed &/or moving cell scenario
  - ✓ Note 1: Addressing LEO will provide the flexibility to also support transparent payload based HAPS based scenarios.
- Transparent payload based GEO scenario addressing UE with GNSS capability
  - ✓ Note 2: Addressing LEO and GEO scenarios will enable NR to support all NGSO scenarios with circular orbit at altitude greater than or equal to 600 km

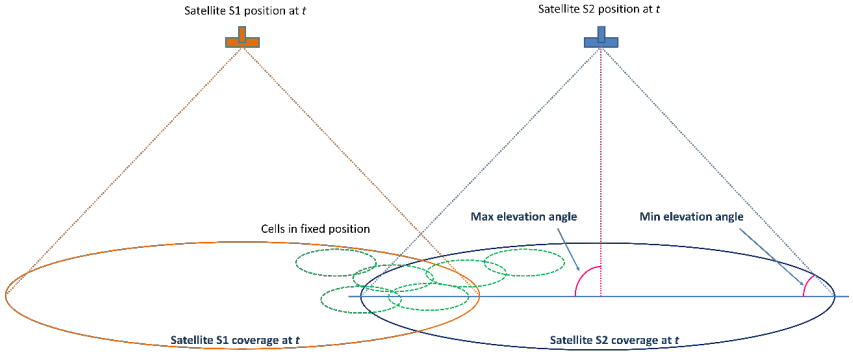
Study activity on NTN scenarios of:

- Transparent payload based HAPS scenarios: Study of enablers for spectrum coexistence with cellular (additional Coresets, PCI confusion mitigation, ..)
- IoT-NTN based scenarios
- NTN-network based location of UE (for regulatory services): identify possible solutions

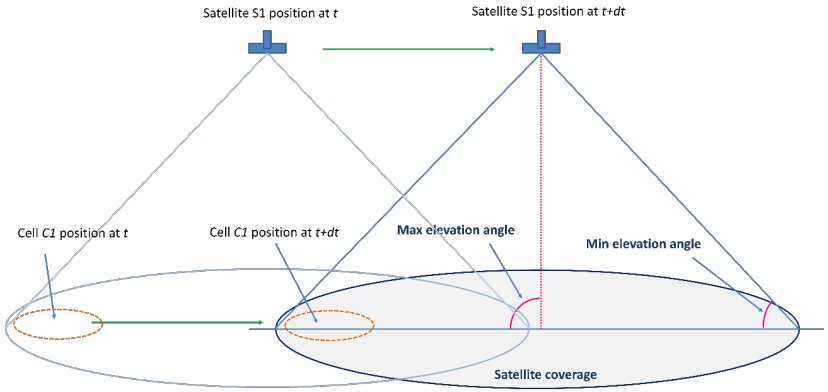
Objective of Rel-17 WI on NTN [3]

Objective of SI or core part WI or testing part WI

- The work item aims to specify the enhancements identified for NR NTN especially LEO and GEO with implicit compatibility to support HAPS (high altitude platform station) and ATG (air to ground) scenarios according to the following principles:
  - ✓ FDD is assumed for core specification work for NR-NTN
    - NOTE: This does not imply that TDD cannot be used for relevant scenarios e.g. HAPS, ATG
  - ✓ Earth fixed Tracking area is assumed with Earth fixed and moving cells
  - ✓ UEs with GNSS capabilities are assumed
  - ✓ Transparent payload is assumed



Earth fixed cells



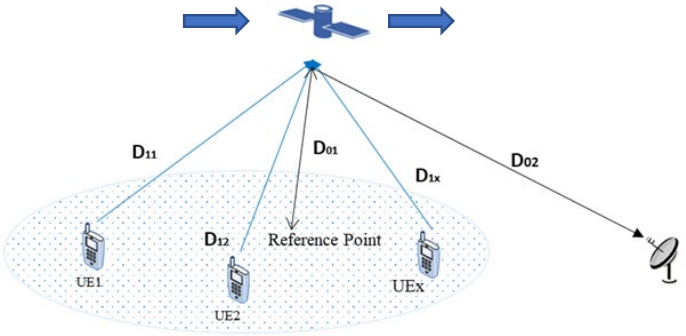
Earth moving cells

Source: R2-1916240 Discussion on Earth fixed vs. Earth moving cells in NTN LEO Nokia

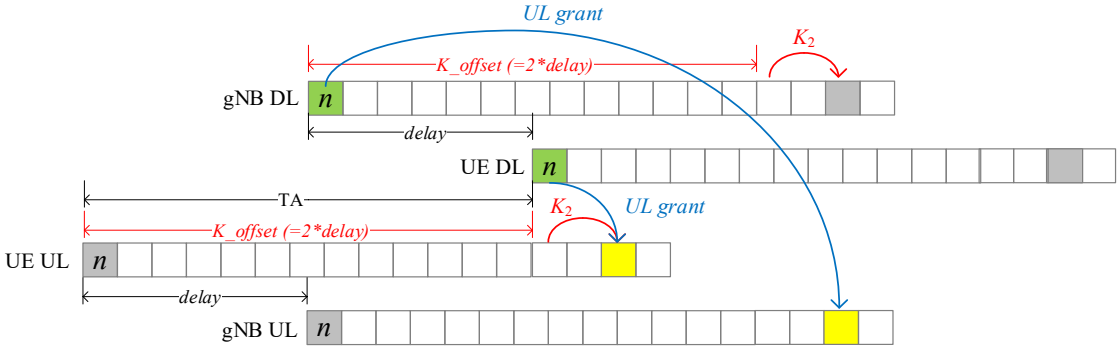
Objective of Rel-17 WI on NTN [3]

Enhancing features to address the identified issues due to long propagation delays, large Doppler effects, and moving cells in NTN

- Timing relationship enhancements [RAN1,RAN2]
- Enhancements on UL time and frequency synchronization [RAN1,RAN2]
- HARQ
  - ✓ Number of HARQ process [RAN1]
  - ✓ Enabling/disabling of HARQ feedback as described in the TR 38.821 [RAN1&2]



Delay & Doppler



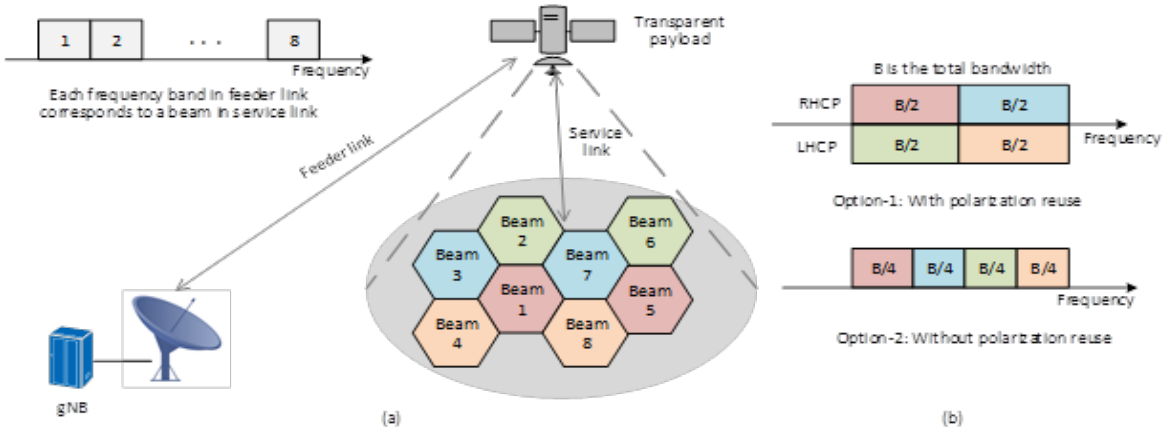
UL time sync. & timing relation

Source: [2]

Objective of Rel-17 WI on NTN [3]

RAN1: if beneficial and needed

- Enhancement on the PRACH sequence and/or format and extension of the ra-ResponseWindow duration (in the case of UE with GNSS capability but without pre-compensation of timing and frequency offset capabilities) [RAN1/2].
- Feeder link switch [RAN2,RAN1]
- Beam management and Bandwidth Parts (BWP) operation for NTN with frequency reuse [RAN1/2]
  - ✓ Including signalling of polarization mode



Beam layout & polarization

Source: R1-2007233 Feature lead summary#4 on other enhancements of NR NTN Moderator (MediaTek)

References

[1] 3GPP TR 38.811 v15.2.0: "Study on New Radio (NR) to support non-terrestrial networks (Release 15),"
[2] 3GPP TR 38.821 v1.0.0, “Solutions for NR to support non-terrestrial networks (NTN) (Release 16),” Dec. 2019.
[3] RP-201256 " Solutions for NR to support non-terrestrial networks (NTN) (Release 17),” e-meeting, June 29 - July 3, 2020.

Appendix

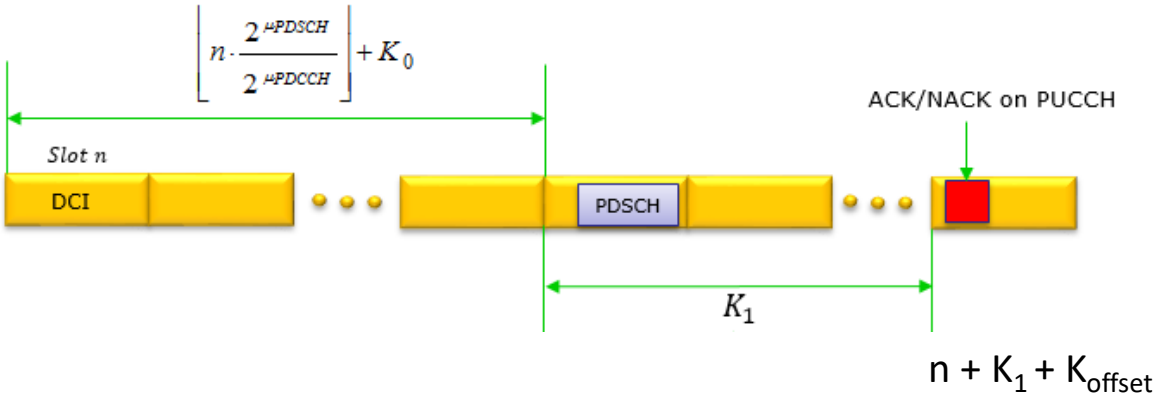
Selected Agreements

Timing Relationship Enhancements

Introducing K_{offset} for timing relationships enhancements Agreement (RAN1#102-e)

- Introduce K_offset to enhance the following timing relationships:
  - ✓ The transmission timing of DCI scheduled PUSCH (including CSI on PUSCH)
  - ✓ The transmission timing of RAR grant scheduled PUSCH
  - ✓ The transmission timing of HARQ-ACK on PUCCH
  - ✓ The CSI reference resource timing
  - ✓ The transmission timing of aperiodic SRS

Note: Additional timing relationships that require K_offset of the same or different values

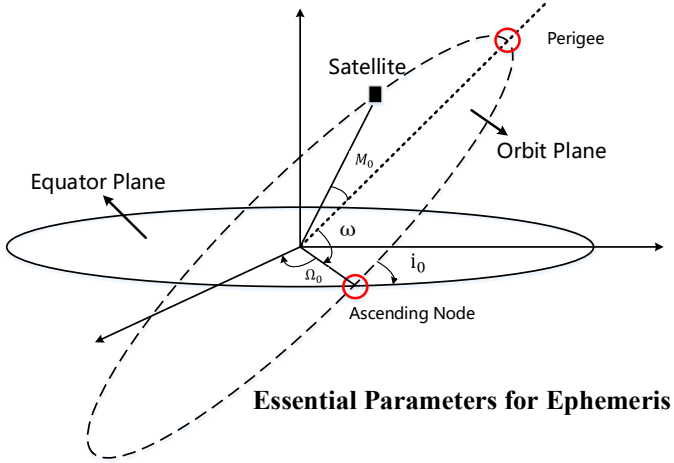


Transmission timing of HARQ-ACK on PUCCH

UL Time Synchronization

Ephemeris information Agreement (RAN1#105-e)

- Specifications should support delivery of ephemeris information using both ephemeris formats, i.e., state vectors and orbital elements



Essential Parameters for Ephemeris

Orbital plane parameters	$\sqrt{a}$	Square root of semi major axis (semi-major axis)
	e	Eccentricity (eccentricity)
	i_0	Inclination angle at reference time (inclination)
	Ω_0	Longitude of ascending node of orbit plane (right ascension of the ascending node)
	ω	Argument of perigee (argument of periapsis)
Satellite level parameters	M_0	Mean anomaly at reference time (true anomaly and a reference point in time)
	t_{0e}	Ephemeris reference time (the epoch)

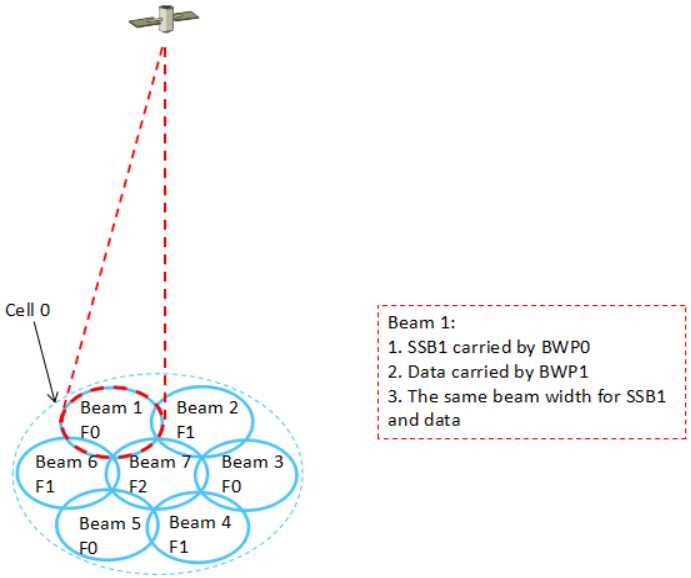
Essential elements of ephemeris

Beam Management

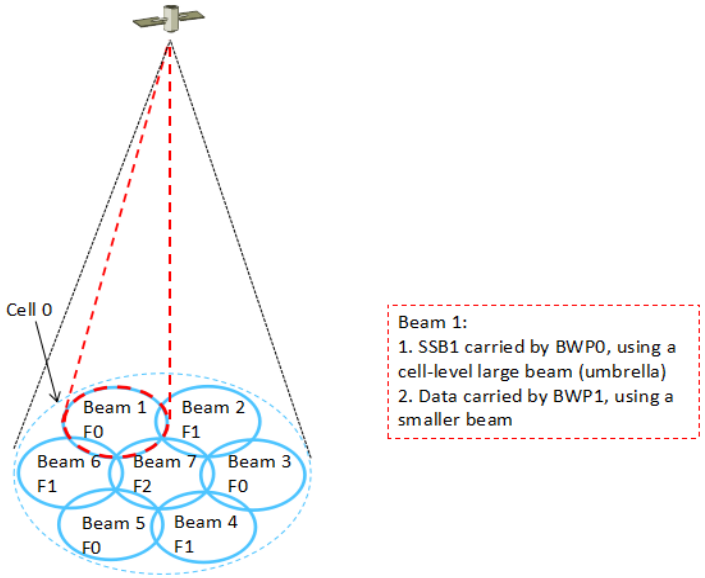
Beam layout

Agreement (RAN1#105-e)

- Same beam layout in BWP#0 and BWP#x (Option 1) and hierarchical beam for BWP#0 (Option 2) should be supported by the specifications for NR-NTN
  - ✓ FFS: Whether any specification changes are needed specifically to support this functionality



(a) **Option-1**: Same beam layout in BWP#0 and BWP#x



(b) **Option-2**: hierarchical beam for BWP#0