

SATELLITE COMMUNICATIONS IN 5G NON-TERRESTRIAL NETWORKS (NTN)

Alexander Hofmann



AGENDA



- **3GPP Standardization**
 - What is 5G?
 - Timeline & Satellite Inclusion
 - Role of NTN
- **Architecture Options**
 - Overview
 - Direct Access
 - Transparent vs. Regenerative Satellite
- **Architecture Elements**
 - NTN Platforms
 - NTN Terminals



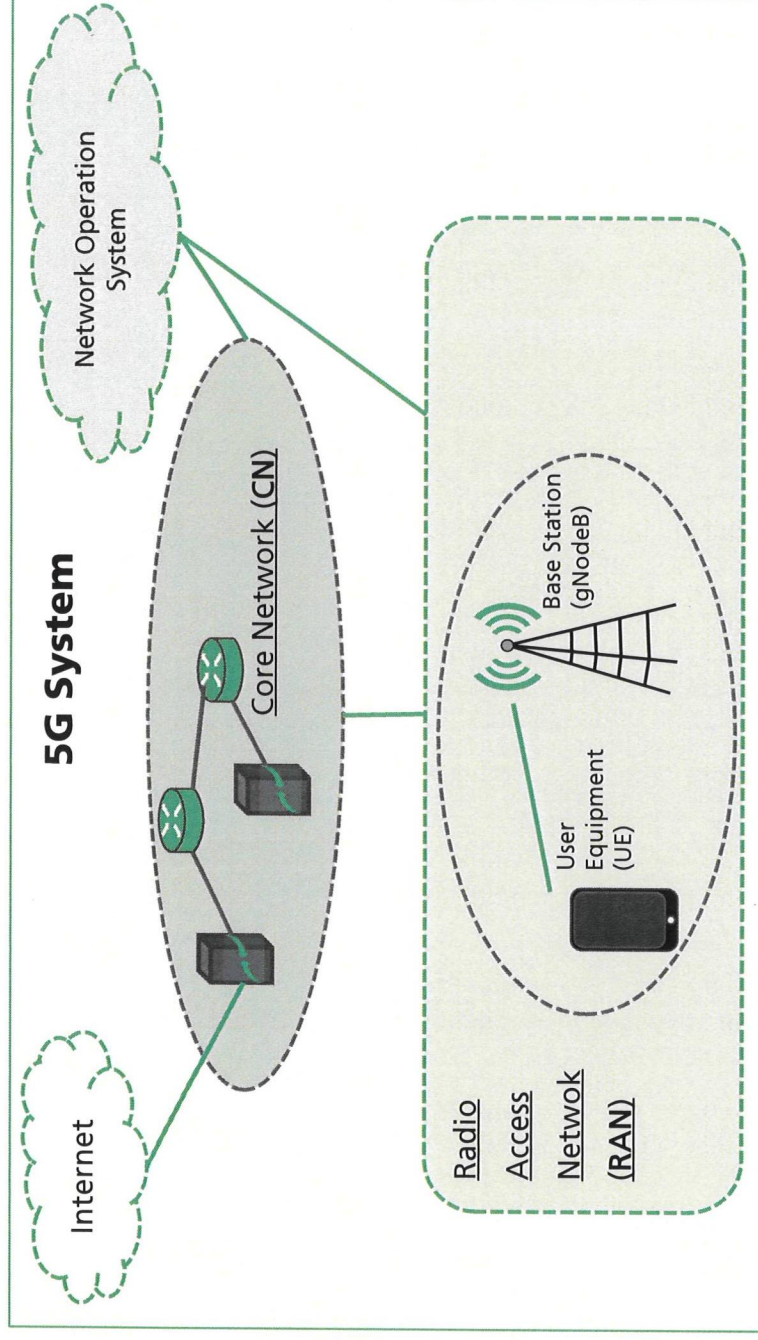
Satellite Communications in 5G

3GPP Standardization: What is 5G?

1 G	2 G	2 ½ G	3 G	3 ½ G	3 ¾ G	4 G	4 ½ G	5 G
1981	1990	1993	2001	2006	2010	2015	2018	2020
C-Netz NMT AMPS TACS	GSM ¹ CDMA IS-95A	GPRS ² IS-95B	EDGE ³ UMTS ⁴ CDMA 2000	HSDPA ⁵ HSPA+ 1xEV-DO	LTE ⁶ Rel. 8	LTE-A ⁷ Rel. 10	LTE-A Pro Rel. 13/14	LTE / NR ⁸ Rel. 15/16
	¹ Global System for Mobile Communication	² General Packet Radio Service	³ Enhanced Data Rate for Global Evolution ⁴ Universal Mobile Telecommunications System	⁵ High Speed Packet Access	⁶ Long Term Evolution	⁷ LTE Advanced		⁸ New Radio

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3GPP Standardization: What is 5G?

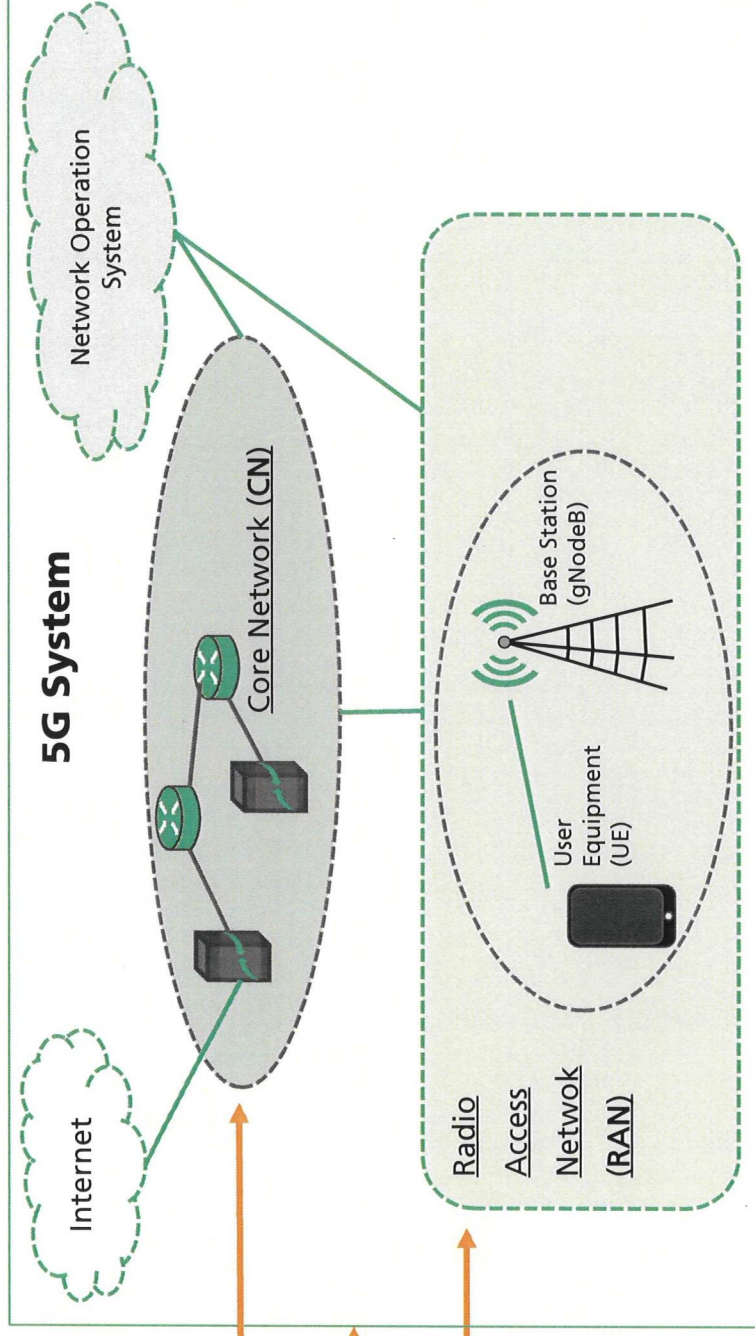


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3GPP Standardization: What is 5G?

Technical Specification Groups

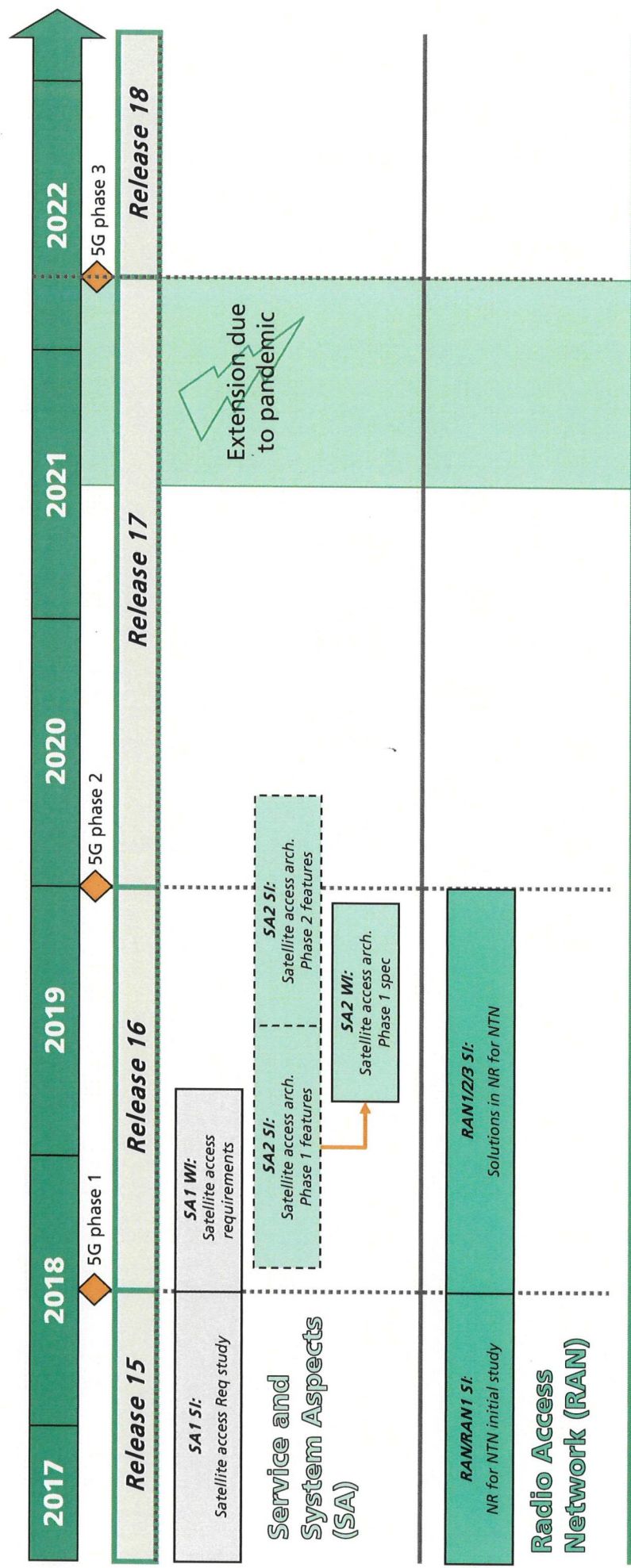
- Core Network & Terminals (CT)
- Service & System Aspects (SA)
- Radio Access Network (RAN)



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3GPP Standardization: Timeline & Satellite Inclusion

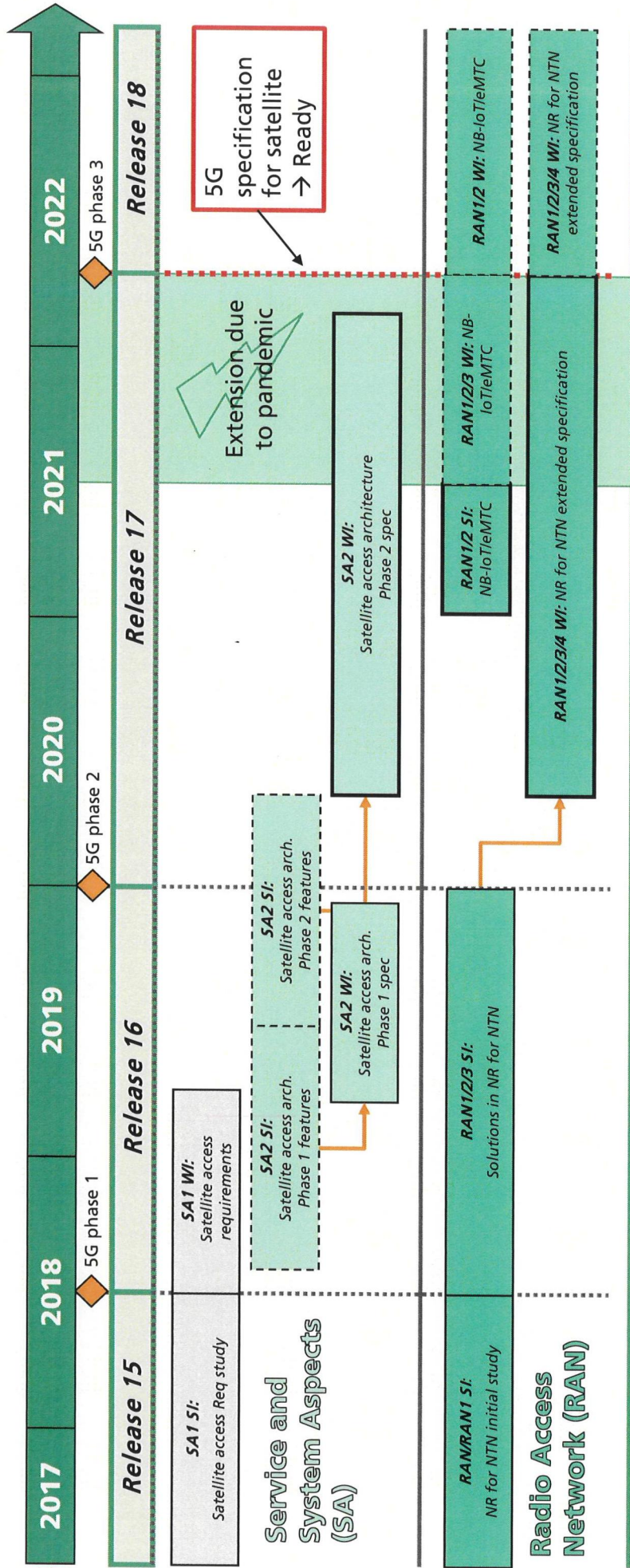
NTN: Non-terrestrial Networks
 SI: Study Item
 WI: Work Item



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3GPP Standardization: Timeline & Satellite Inclusion

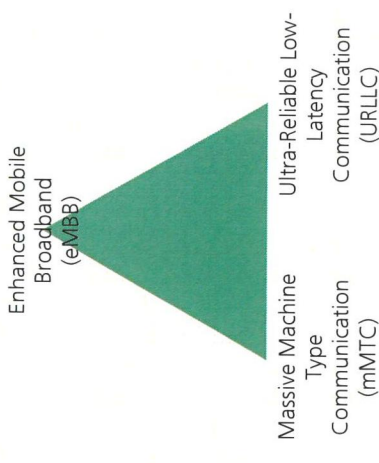
NTN: Non-terrestrial Networks
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3GPP Standardization: Role of NTN

- NTN in 5G are expected to:
 - Foster the roll out of 5G service in:
 - Un-served areas (isolated/remote areas, on board aircrafts or vessels)
 - Underserved areas (e.g. sub-urban/rural areas)
 - Reinforce the 5G service reliability for:
 - M2M/IoT devices
 - Passengers on board moving platforms (cars, trains, aircrafts, ships)
 - Ensuring service availability anywhere (especially for critical or future railway/maritime/aeronautical communications)
 - Enable 5G network scalability by providing efficient multicast/broadcast resources for data delivery towards the network edges or even user terminal.



Satellite Communications in 5G

Architecture Options: Overview

- 1) Backhaul
- 2) Indirect Access
 - a) Transparent / Bent-pipe satellite
 - b) 5G enabled satellite
- 3) Direct Access
 - a) Transparent / Bent-pipe satellite
 - b) 5G enabled satellite

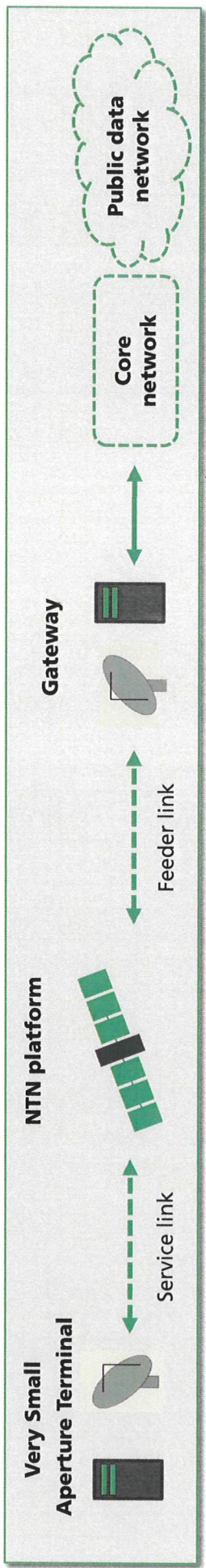
Satellite Communications in 5G Architecture Options: Overview

- 1) Backhaul
 - ↑ Not new!
- 2) Indirect Access
 - a) Transparent / Bent-pipe satellite
 - b) 5G enabled satellite
 - ↑ Postponed, due to ongoing* WI on IAB (Integrated Access and Backhaul)
- 3) Direct Access
 - a) Transparent / Bent-pipe satellite
 - b) 5G enabled satellite
 - ↑ With first priority on transparent / bent-pipe satellite architecture;
5G enable satellite in future upcoming releases

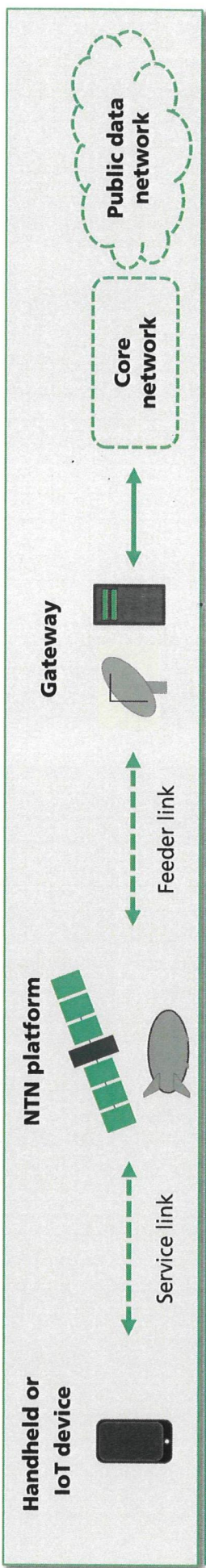
*ongoing at the time of the decision

Satellite Communications in 5G Architecture Options: Direct Access

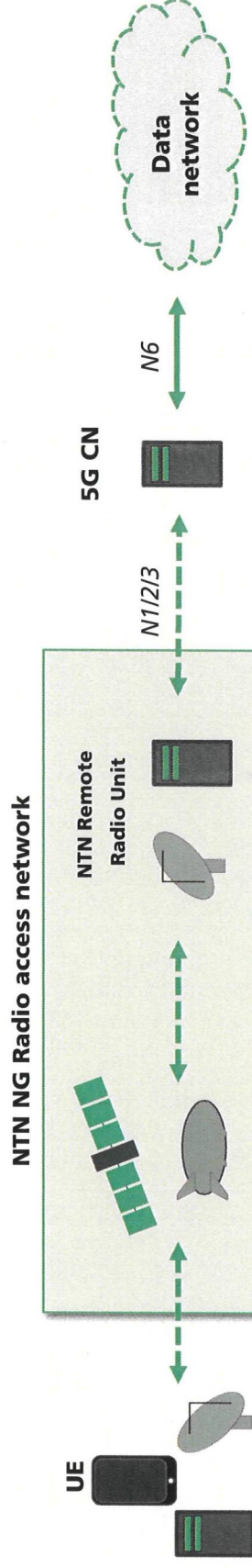
- Satellite access network (w/ & w/o ISL) above 6 GHz frequency bands allocated to Fixed and Mobile Satellite Services (FSS and MSS):



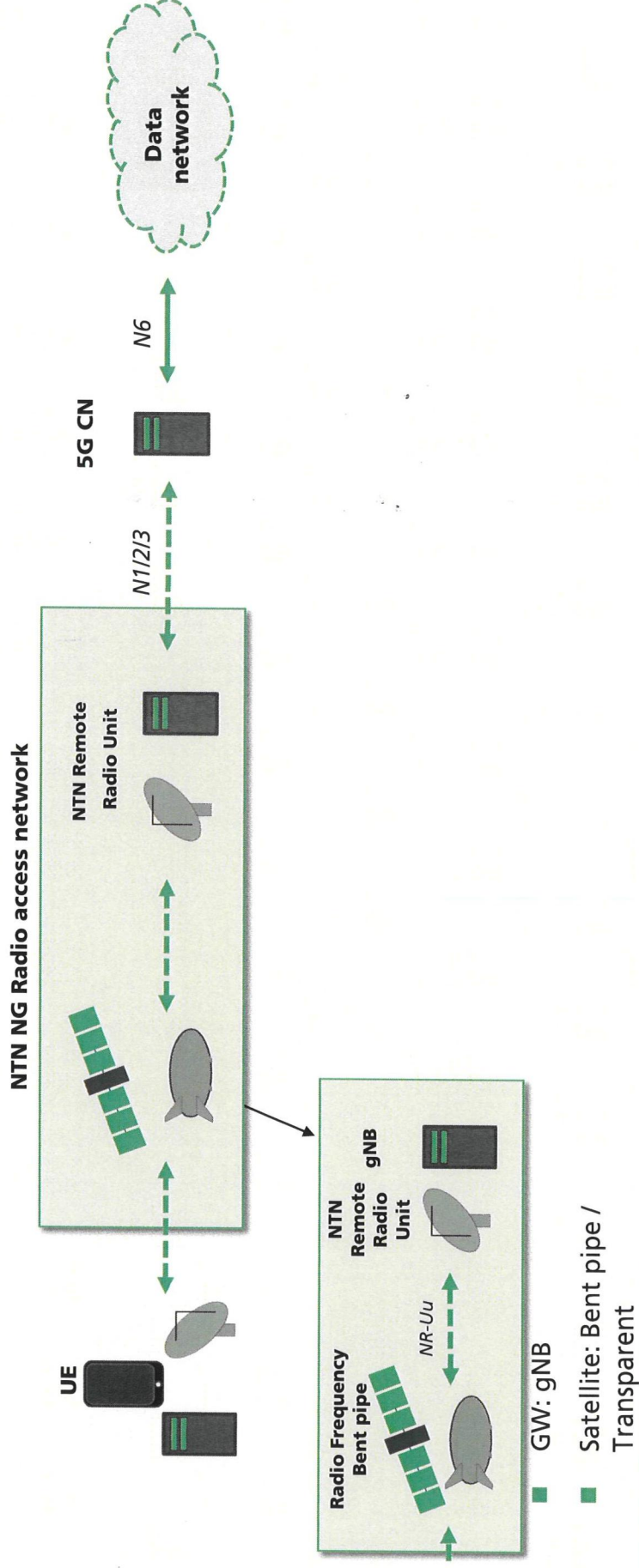
- Satellite access network below 6 GHz frequency bands allocated to Mobile Satellite Services (MSS):



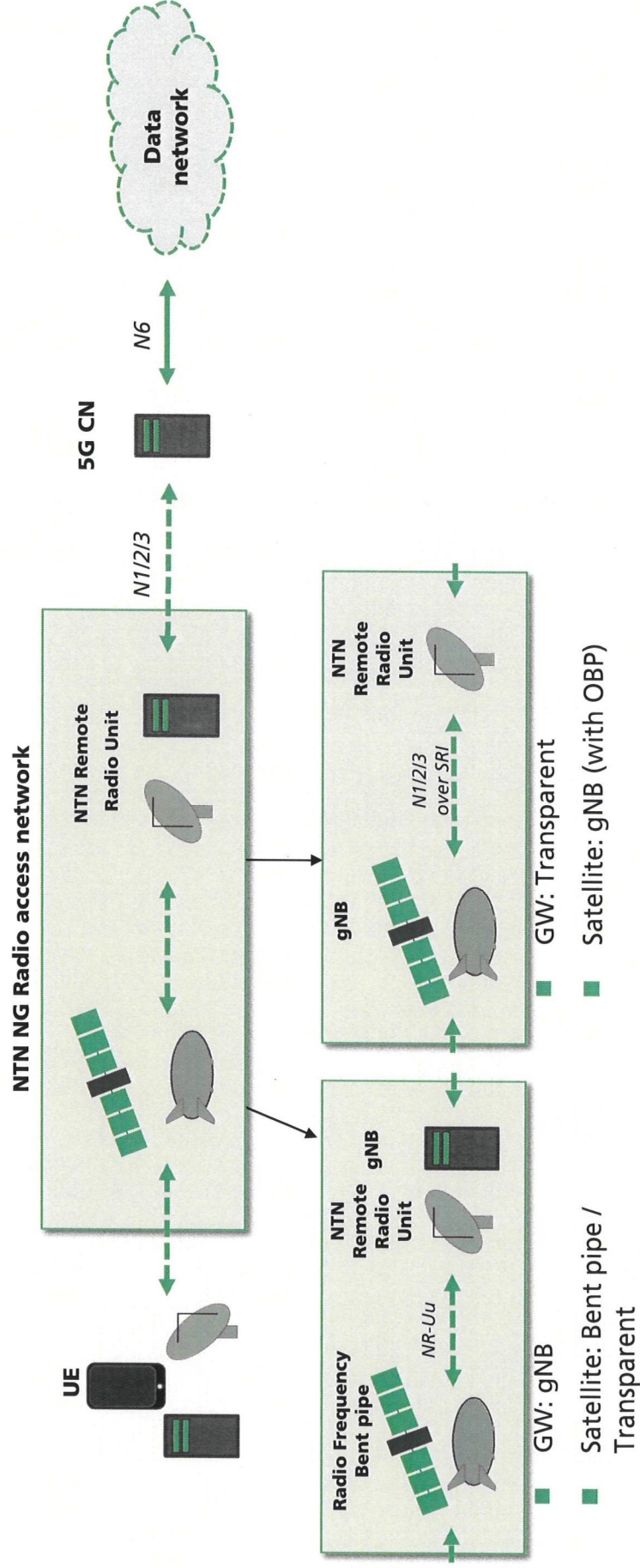
Satellite Communications in 5G Architecture Options: Transparent vs. Regenerative Satellite



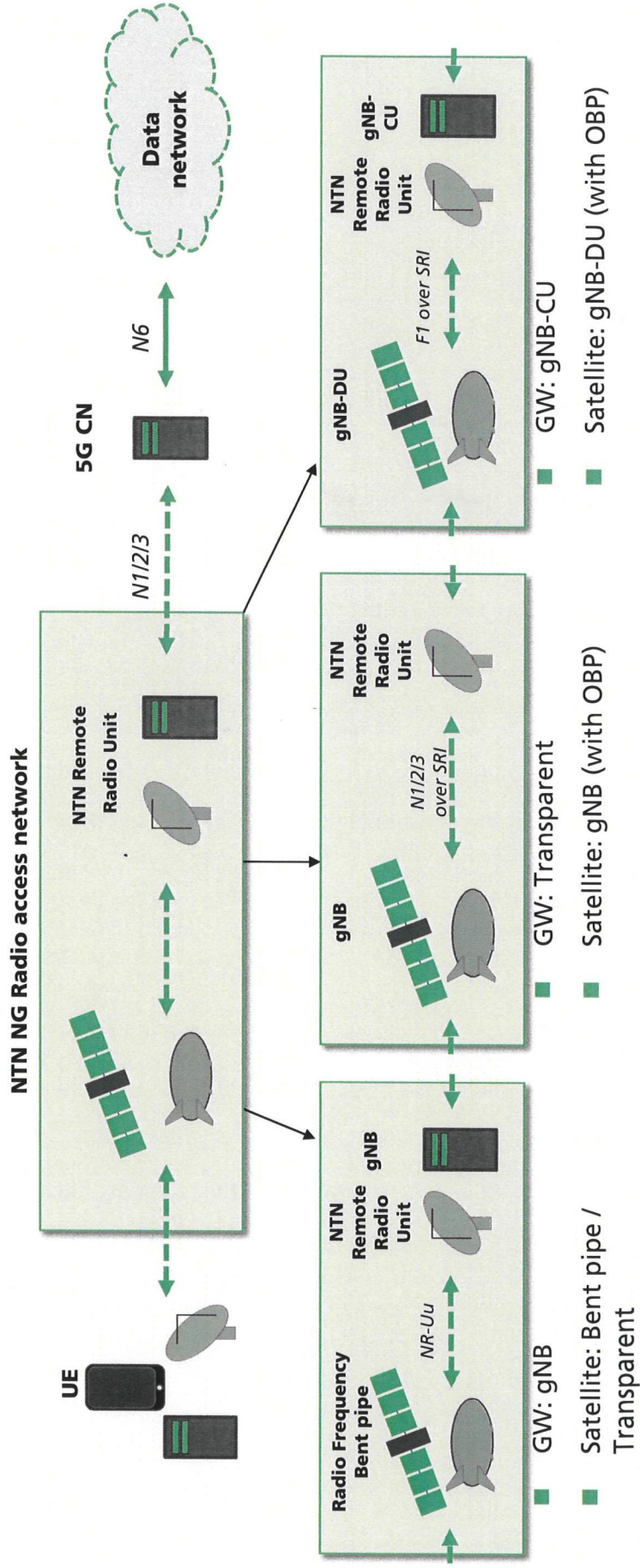
Satellite Communications in 5G Architecture Options: Transparent vs. Regenerative Satellite



Satellite Communications in 5G Architecture Options: Transparent vs. Regenerative Satellite



Satellite Communications in 5G Architecture Options: Transparent vs. Regenerative Satellite



Satellite Communications in 5G Architecture Elements: NTN Terminals

	Very Small Aperture Terminal (fixed or mounted on moving platforms)	Handheld or IoT devices (3GPP class 3, see [1])
NTN Platforms	GEO, MEO (NOTE 1), LEO (> 600 km altitude)	GEO, MEO (NOTE 1), LEO (> 600 km altitude)
Frequency band	FR1 (< 6GHz) FR2 (> 6 GHz, e.g. Ka band)	FR1 (< 6GHz, e.g. S band)
Bandwidth range	50 – 400 MHz (RB from 720 kHz)	5 – 100 MHz (RB from 180 kHz)
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 2)	18.5 dB/K	-33.6 dB/K

NOTES

NOTE 1: MEO (and also GEO) is possible in general.
In NR NTN Work Item the link-budgets

NOTE 2: For the computation of G/T or figure of merit, following formula applies in dB:

$$G/T = G_a - NF - 10 * \text{LOG} (T_o + (T_a - T_o) / (10^{0.1 * NF}))$$

Where:

- Antenna Gain : G_a in dBi
- Ambient Temperature : T_o (usually 290 K)
- Antenna temperature : T_a (typically 290 K with 0 dBi gain and 150 K with >30 dBi gain)
- Noise Figure: NF in dB

References

[1] 3GPP TS 36.101, V17.1.0: "Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 17)"; 2021-03

Satellite Communications in 5G

Summary & Outlook

- 3GPP Standardization:
 - Initial 5G standard for satellites available in Rel-17 (Q1/2022) → narrowband and broadband
 - Fraunhofer IIS is member of ESA ALIX standardization project to support satellites
- Prototyping and Demonstration:
 - Successful Pre-Release-17 technology live demonstration over GEO satellite by Fraunhofer IIS (PR: https://www.iis.fraunhofer.de/en/pr/2021/20210312_5G_new_radio.html)
- Long term perspective:
 - Extensions for NTN planned in Rel-18 (standardization in 2022/2023)
 - Spectrum sharing will become important
 - 6G will continue to integrate Satellites!

Satellite Communications in 5G

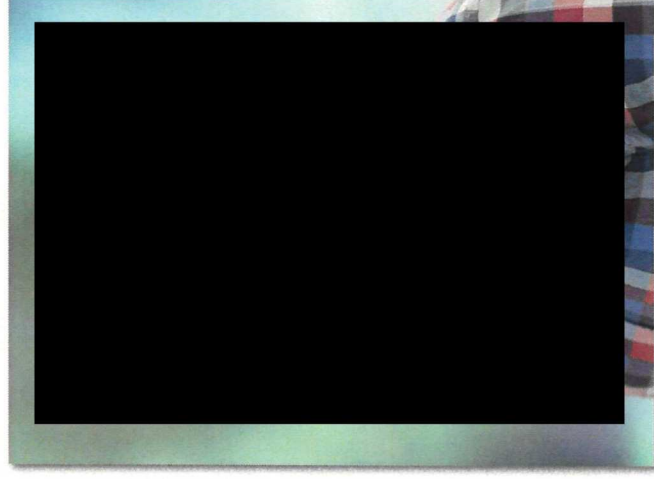
Contact Details

Fraunhofer Institute IIS, Am Wolfsmantel 33, 91058 Erlangen, Germany

Email [Redacted]

Phone [Redacted]

Mobile [Redacted]



Satellite Communications in 5G

References: 3GPP Documentation

SA/RAN	Title	SID / WID	Result	Status (target date)
SA1	Study on using Satellite Access in 5G	SP-170702	TR 22.822	Finished (2018-06)
SA1	Service requirements for next generation new services and markets	SP-180326	TS 22.261	Finished, v17.0.1 (2019-10)
SA2	Study on architecture aspects for using satellite access in 5G	SP-180505	TR 23.737	Finished, v17.1.0 (2020-07)
SA2	Integration of satellite components in the 5G architecture	SP-191335	TS 23.501, 502, 503	On-going until 2021-12
SA5	Study on management and orchestration aspects with integrated satellite components in a 5G network	SP-190138	TR 28.808	Finished, v17.0.0 (2021-04)
RAN / RAN1	Study on New Radio (NR) to support non terrestrial networks	RP-171450	TR 38.811	Finished, v15.4.0 (2020-10)
RAN3 lead	Study on solutions for NR to support non-terrestrial networks (NTN)	RP-190710	TR 38.821	Finished, v16.0.0 (2020-01)
RAN2 lead	Solutions for NR to support non-terrestrial networks (NTN)	RP-210908	TS 38.xyz	On-going until 2022-03
RAN1 lead	Study on NB-IoT/eMTC support for Non-Terrestrial Networks	RP-210868	TR 36.763	On-going until 2021-06