



TNO innovation
for life

SATCOM DEVELOPMENTS IN 3GPP

KIVI SEMINAR: SATELLITE COMMUNICATIONS FOR 5G AND BEYOND

NOVEMBER 7, 2023

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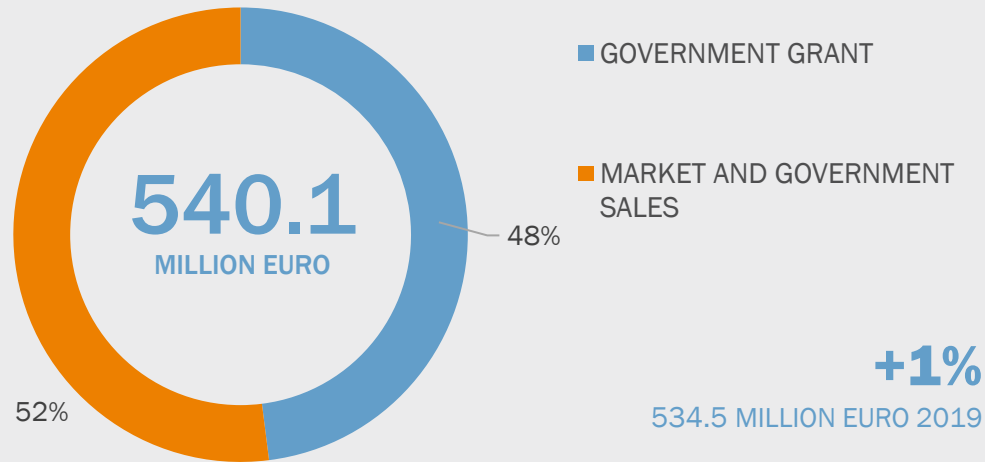
› **OVERVIEW**

- › TNO in a nutshell
- › 3GPP
- › Satcom role in 5G
- › Integration of satellite into 5G - challenges
- › Status and way forward

TNO

TNO - independent research organisation focusing on applied science (established 1932)

REVENUE ORGANISATION TNO (INCL. GOVERNMENT GRANT)

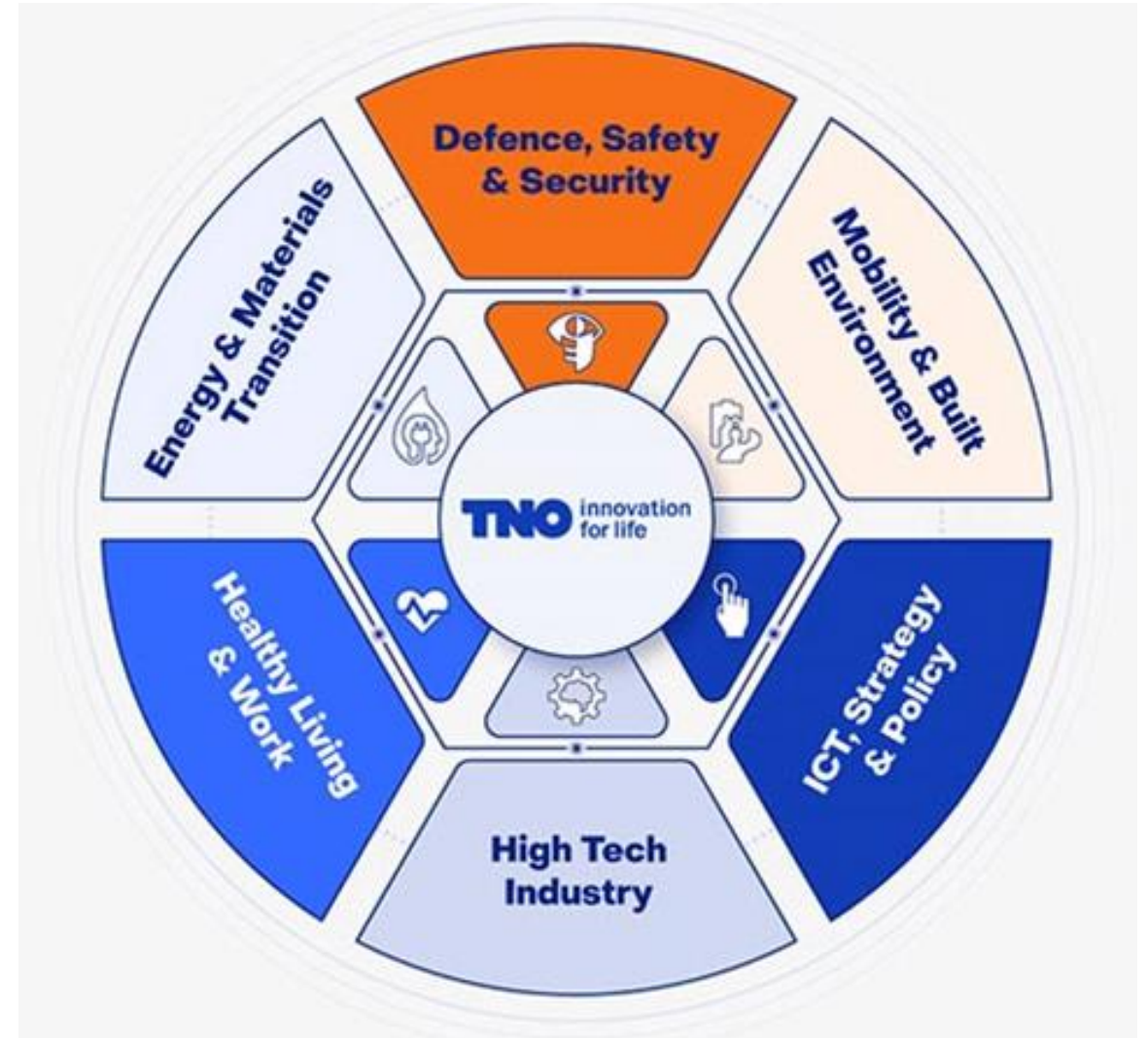


NUMBER OF EMPLOYEES

3,562
TOTAL



3,431 2019



TNO NETWORKS DEPARTMENT

TNO 5G LAB AND FIELD LABS



Field lab for warehouse/logistics

- Drone capable of autonomous stock counting in a warehouse

AR/VR for remote support

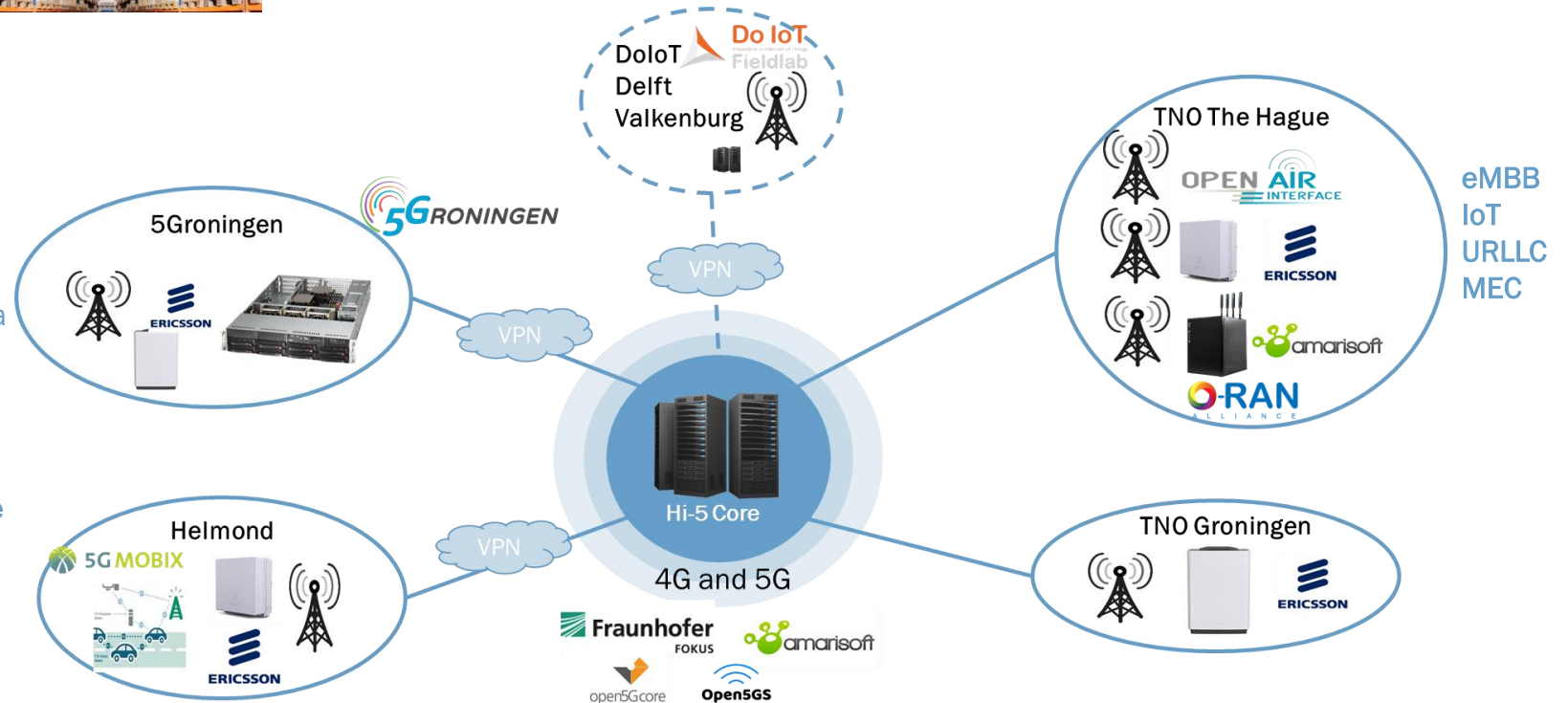
- XR Collaborative Maintenance
- Ambulance with remote medical support (video, medical imaging via ultrasound probe)

Field lab for connected mobility / automotive

- V2V for vehicle platooning via LTE-V2X
- Traffic safety via V2N with edge computing and edge interconnect
- Cross-border roaming with seamless handover

Field lab for IoT

- Unmanned Valley: UAV control/video in 5G (indoor/outdoor)
- NB-IoT and LTE-M in 700 MHz band (2x3 MHz)
- IoT for green Village



› 3GPP

- › 3rd Generation Partnership Project
- › Established in 1998

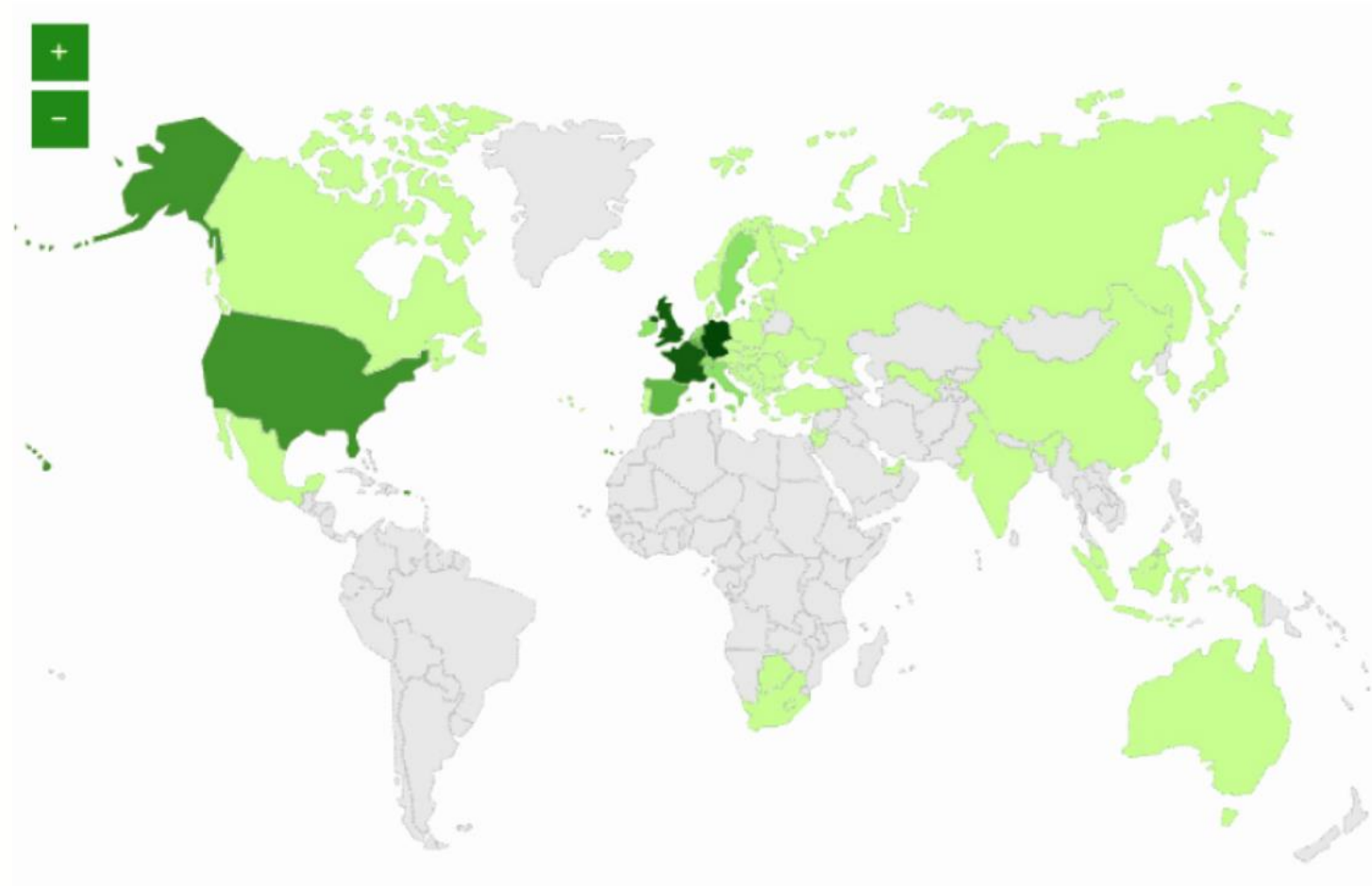


930
Members

61
Countries

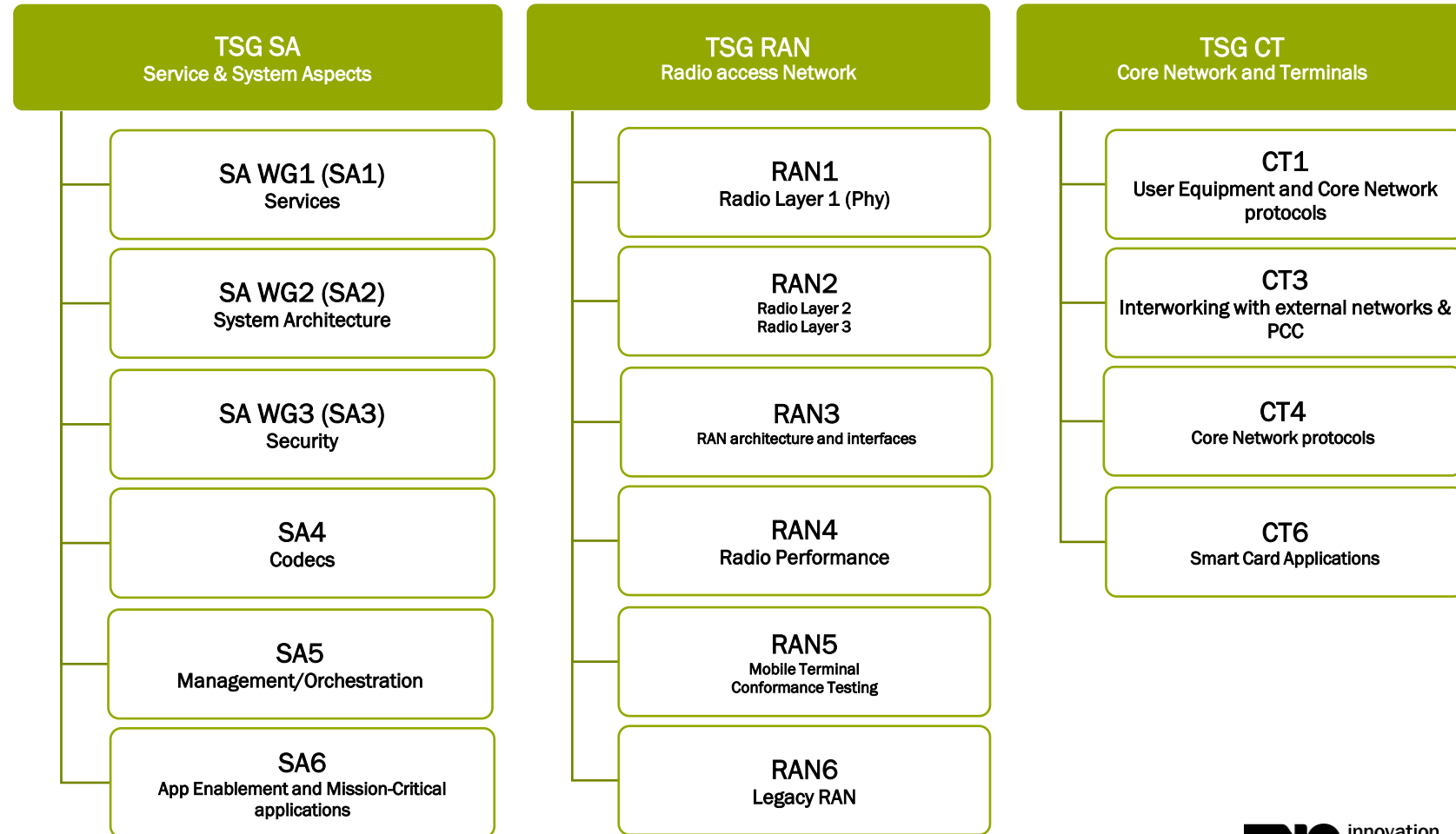
50
Standardization Groups

52312
Standards Published

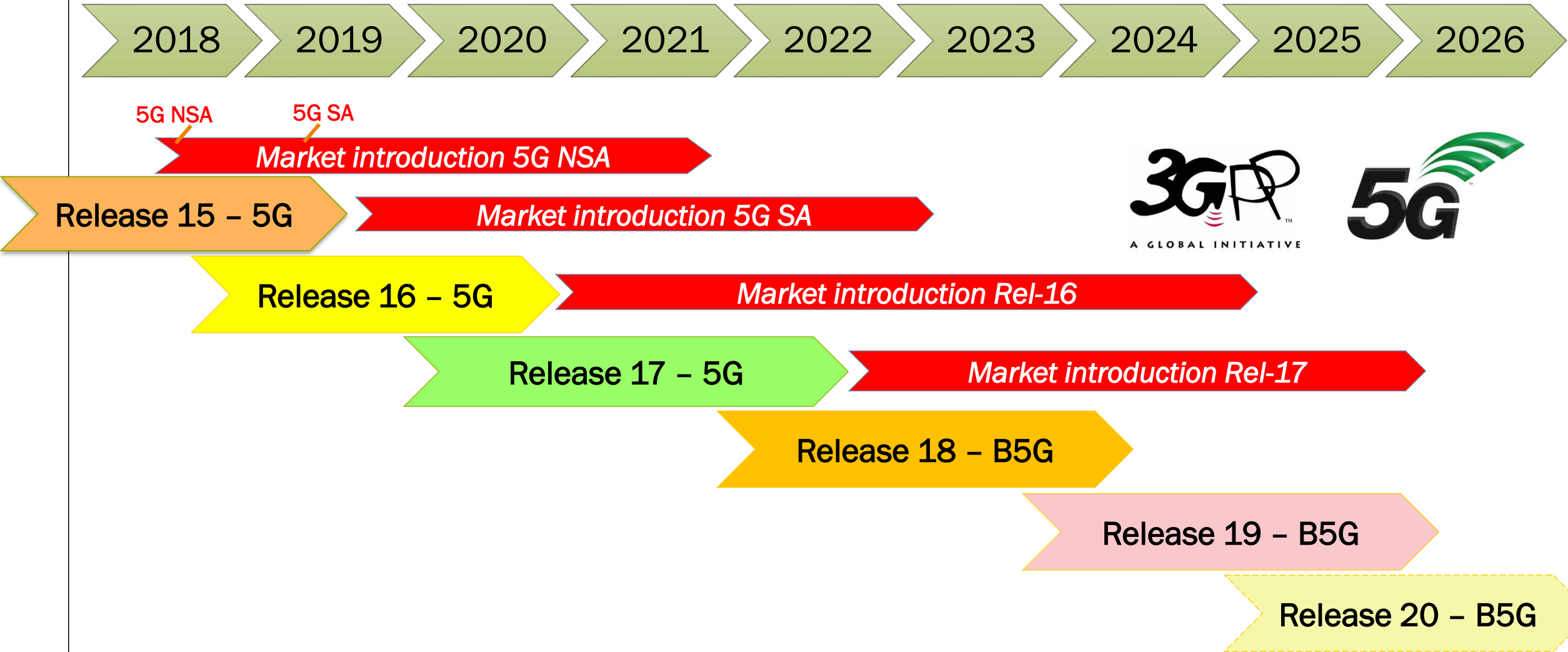


› 3GPP

- › Technical Specification Groups (TSGs): SA, RAN and CT
- › Working Groups

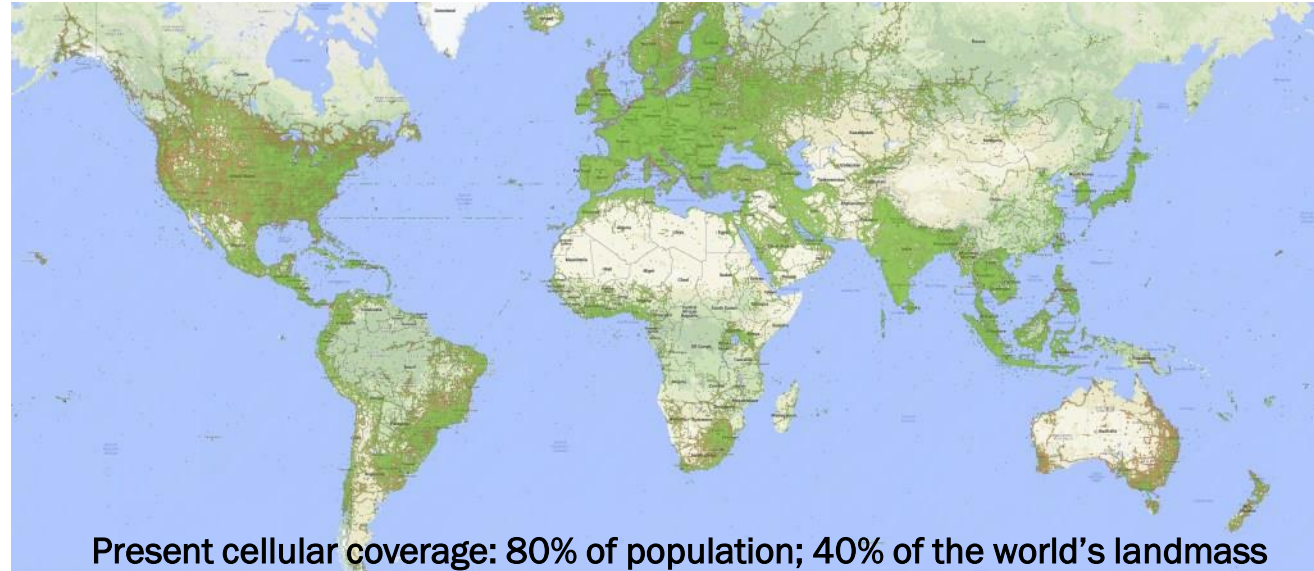


5G STANDARDS: 3GPP MULTI RELEASE TIME PLAN



› SATCOM ROLE IN 5G

- › Providing truly global coverage
- › Improved reliability, resilience
- › 5G standard facilitates
 - Access to economies of scale
 - Seamless handover among access technologies
 - Multi-vendor interoperability
 - Wider ecosystem



5G NTN in 3GPP standard – beneficial for both 5G and Satcom community.

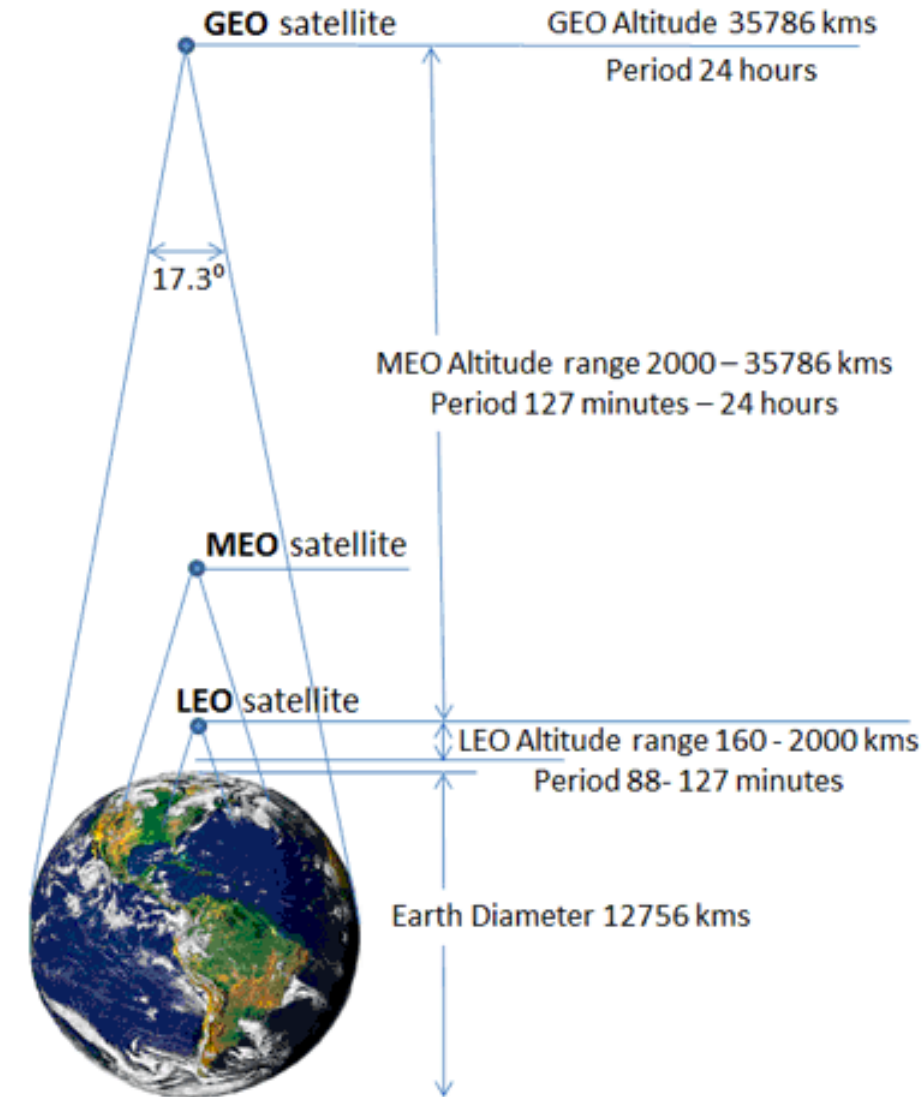
› NTN PLATFORM TYPES

- › Non-terrestrial networks (NTN) comprise satellite and HAPS

Satellite	Altitude range [km]	Orbit	Beam footprint size [km]
Low-Earth Orbit (LEO)	300 - 1500	Circular around the earth	100 - 1000
Medium-Earth Orbit (MEO)	7000 - 25000		100 - 1000
Geostationary Earth Orbit (GEO)	35 786	Fixed position	200 - 3500
High Altitude Platforms (HAPS)	~20		5 - 200

Source: 3GPP TR 38.811 Study on New Radio (NR) to support non-terrestrial networks

Satellite Orbits, Periods and Footprints



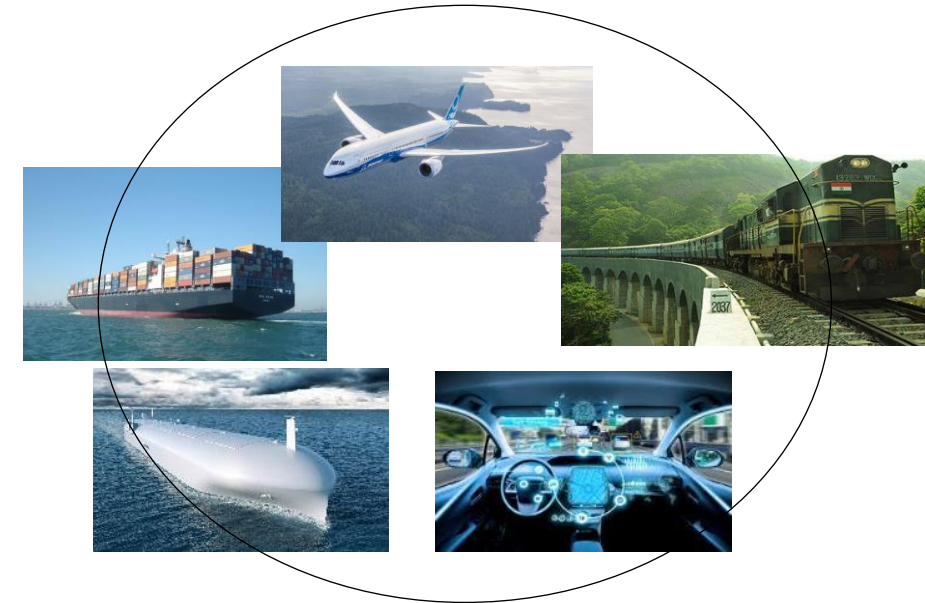
› 5G NTN USE CASES



Range extension



NTN IoT/mMTC



(Autonomous) Moving platforms
Global roaming



Disaster communication
(floods, earthquake, forest fire)
Public Safety
First Responders



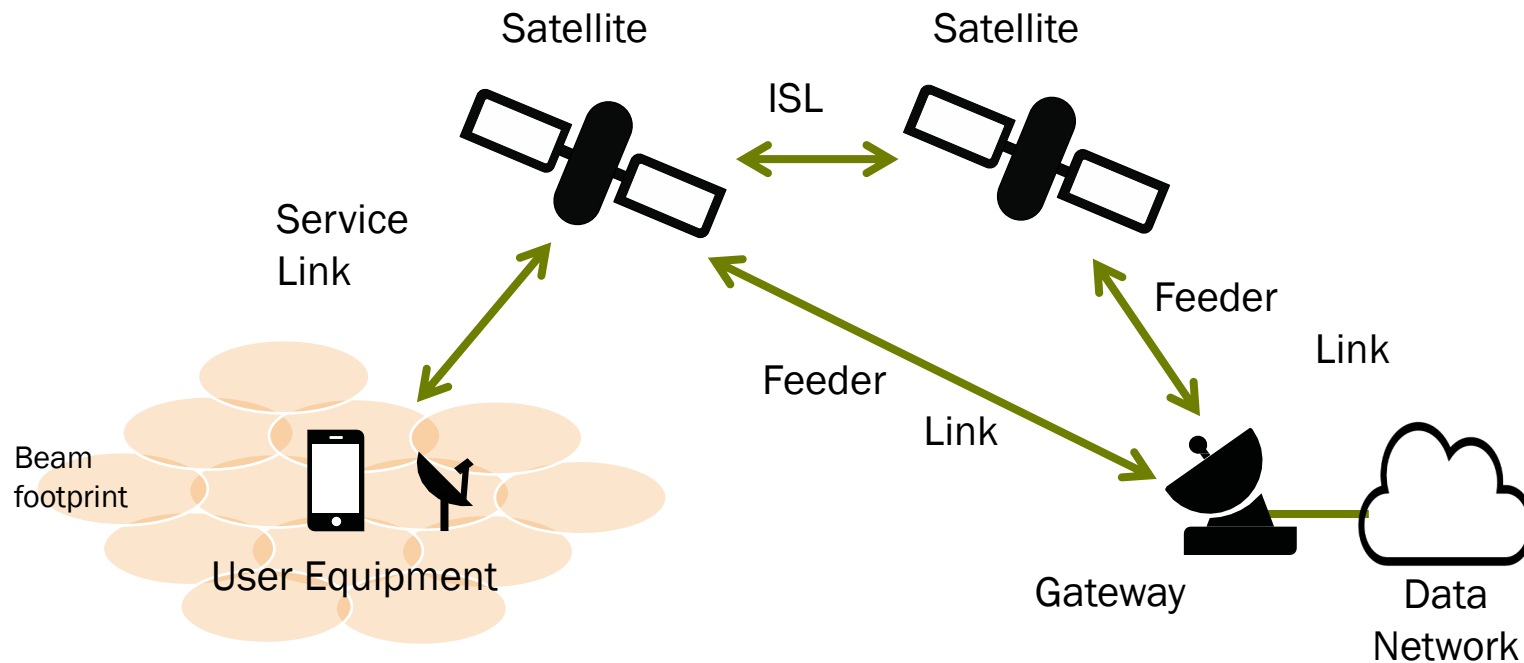
Broadcast
Content to the Edge

5G NTN TARGET PERFORMANCES

Usage scenarios	Experience data rate		Max UE speed	Environment	UE categories
	DL	UL			
IoT connectivity	2 kbps	10 kbps	0 km/h	Extreme coverage	IoT
Pedestrian	2 Mbps	250 kbps	3 km/h	Extreme coverage	Handheld
Public safety	3.5 Mbps	3.5 Mbps	100 km/h 250km/h	Open area	Handheld Vehicle mounted
Stationary	50 Mbps	25 Mbps	0 km/h	Extreme coverage	Building mounted
Vehicular connectivity	50 Mbps	25 Mbps	250 km/h	Along roads in low population density areas	Vehicle mounted
Airplanes connectivity	360 Mbps	180 Mbps	1000 km/h	Open area	Airplane mounted

LEGACY SATELLITE SYSTEMS

TRANSPARENT VS REGENERATIVE



User equipment:

- Satellite terminal (dish, VSAT)
- Satellite handheld device
- Satellite IoT device

Transparent: limited processing capabilities:

- 1) Frequency conversion/shifting
- 2) Amplification
- 3) Filtering

Regenerative - with on board processing:

- 1) - 3) and
- 4) Signal demodulation/modulation
- 5) Adaptive routing (ISL)

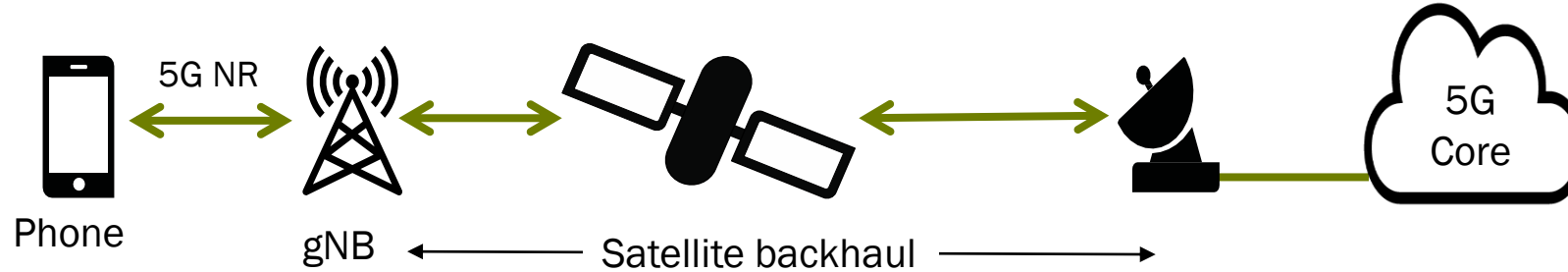


Increased system flexibility, signal quality and capacity.

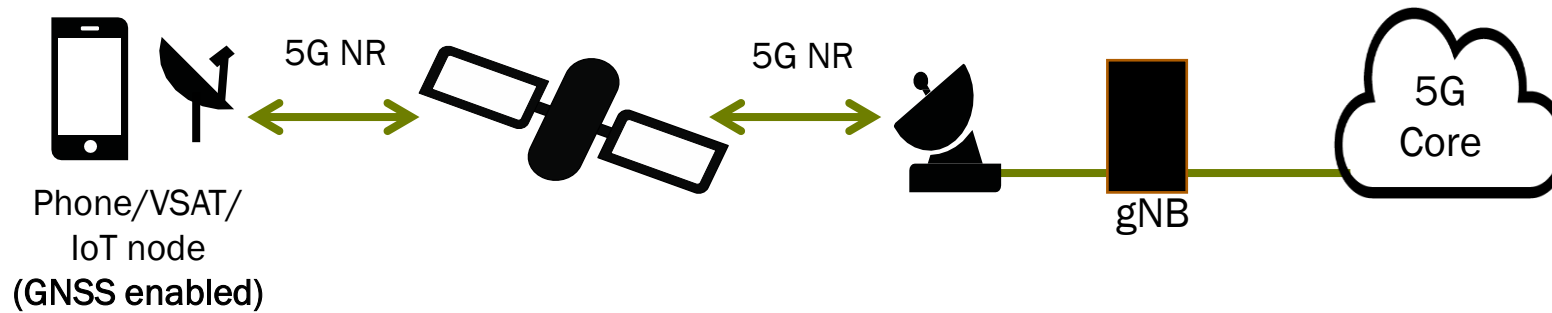
5G NTN SCENARIOS

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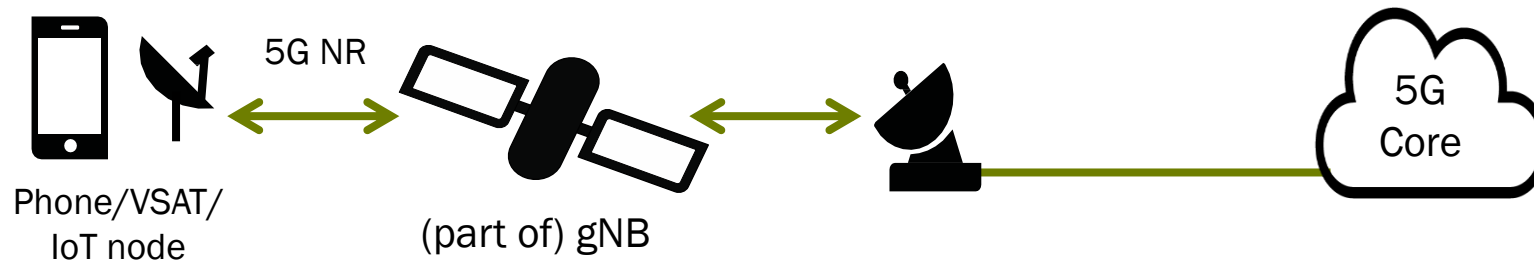
2
0
2
4



Satellite backhaul to a remote 5G base station (gNB).



Transparent satellite (direct access)

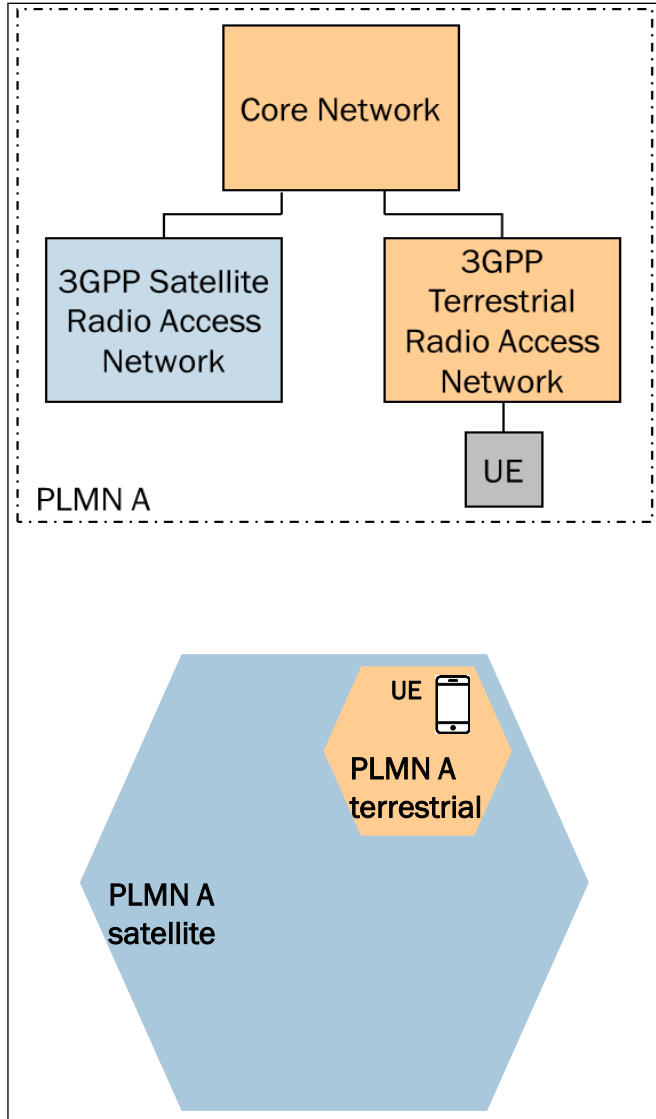


Regenerative satellite (direct access)

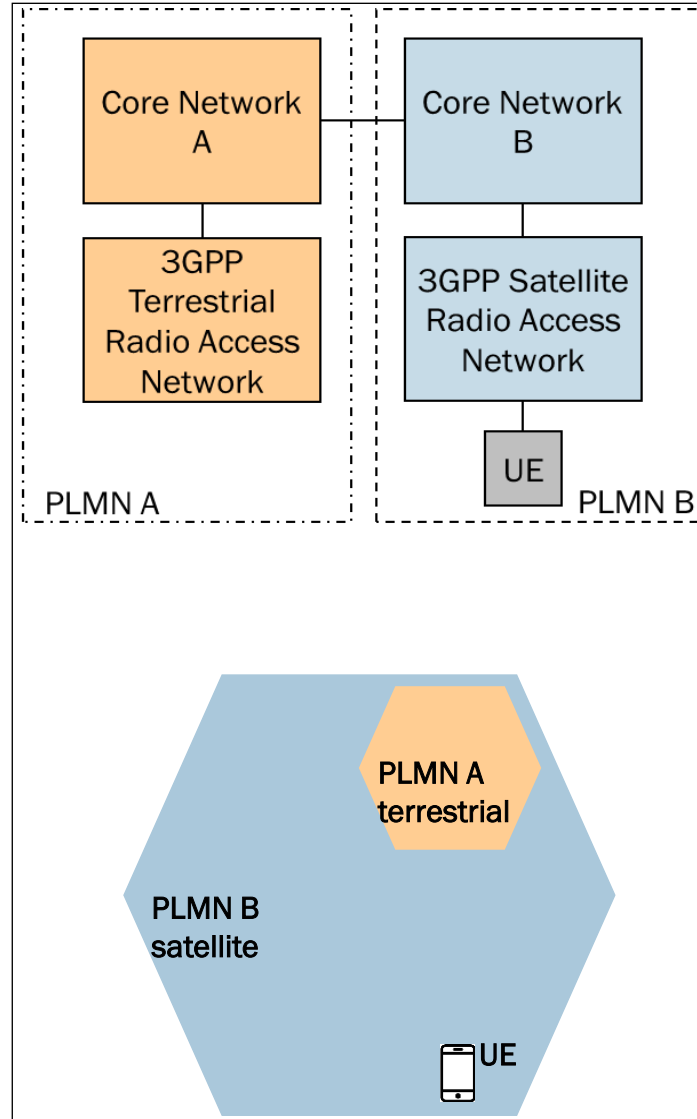
3GPP approach: Integrate satellite in 5G with minimal impact on User Equipment and Network Infrastructure!

5G TN-NTN INTEGRATION SCENARIOS

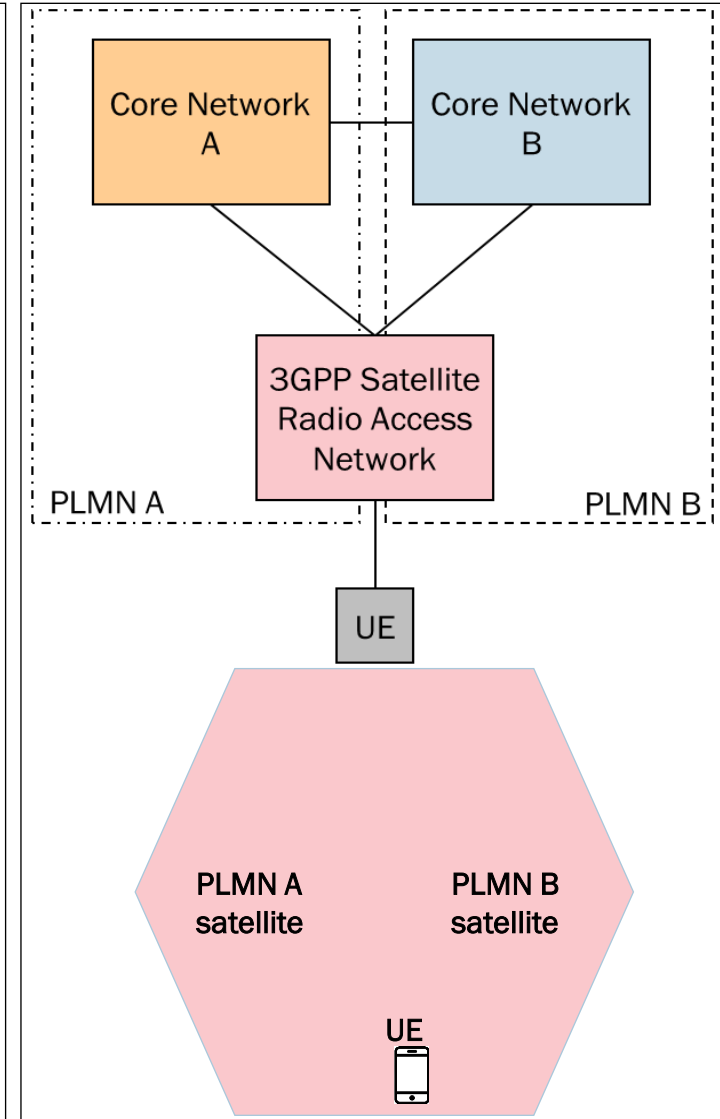
NTN access within a PLMN



Roaming between TN and NTN



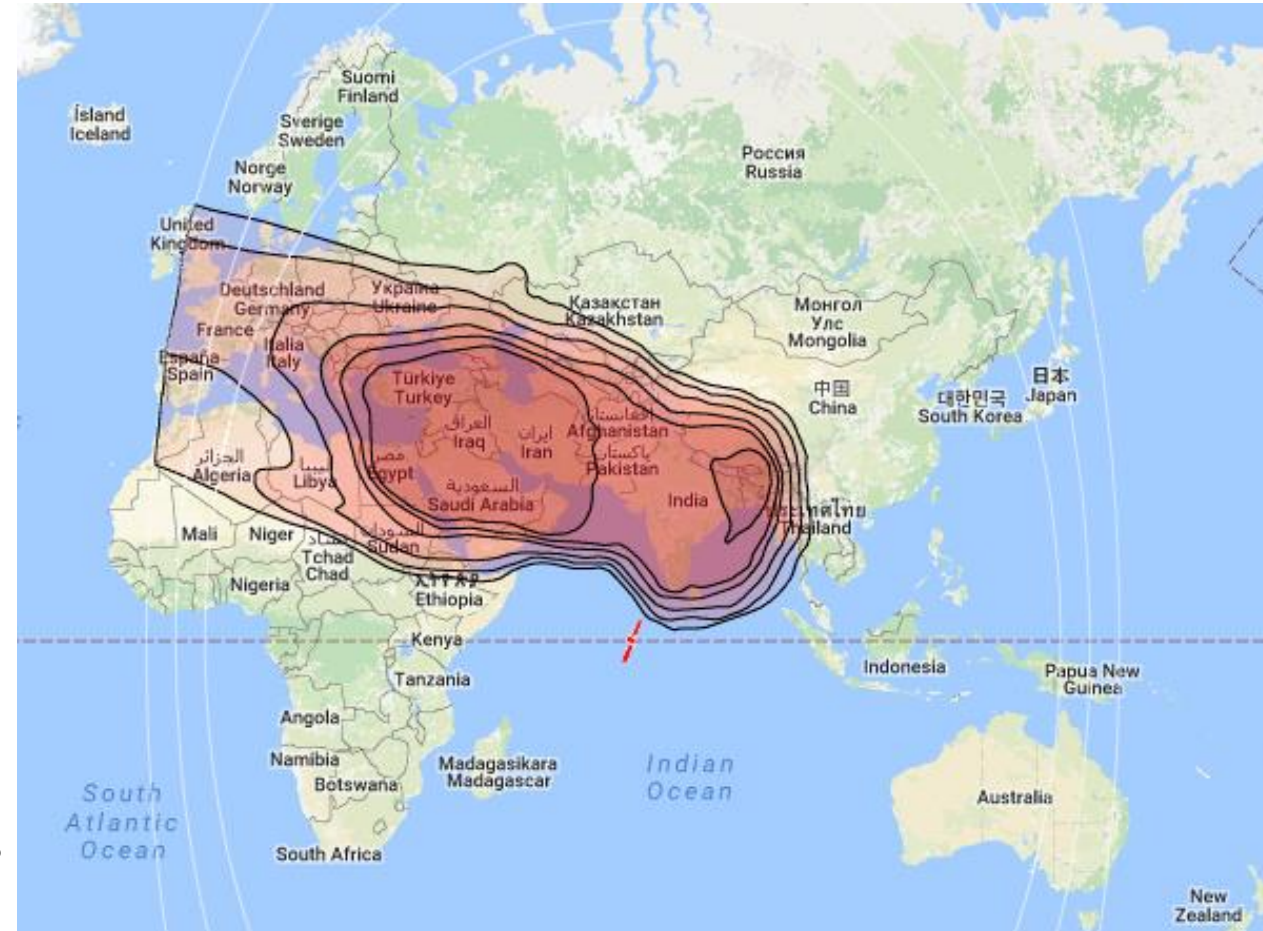
Shared NTN access



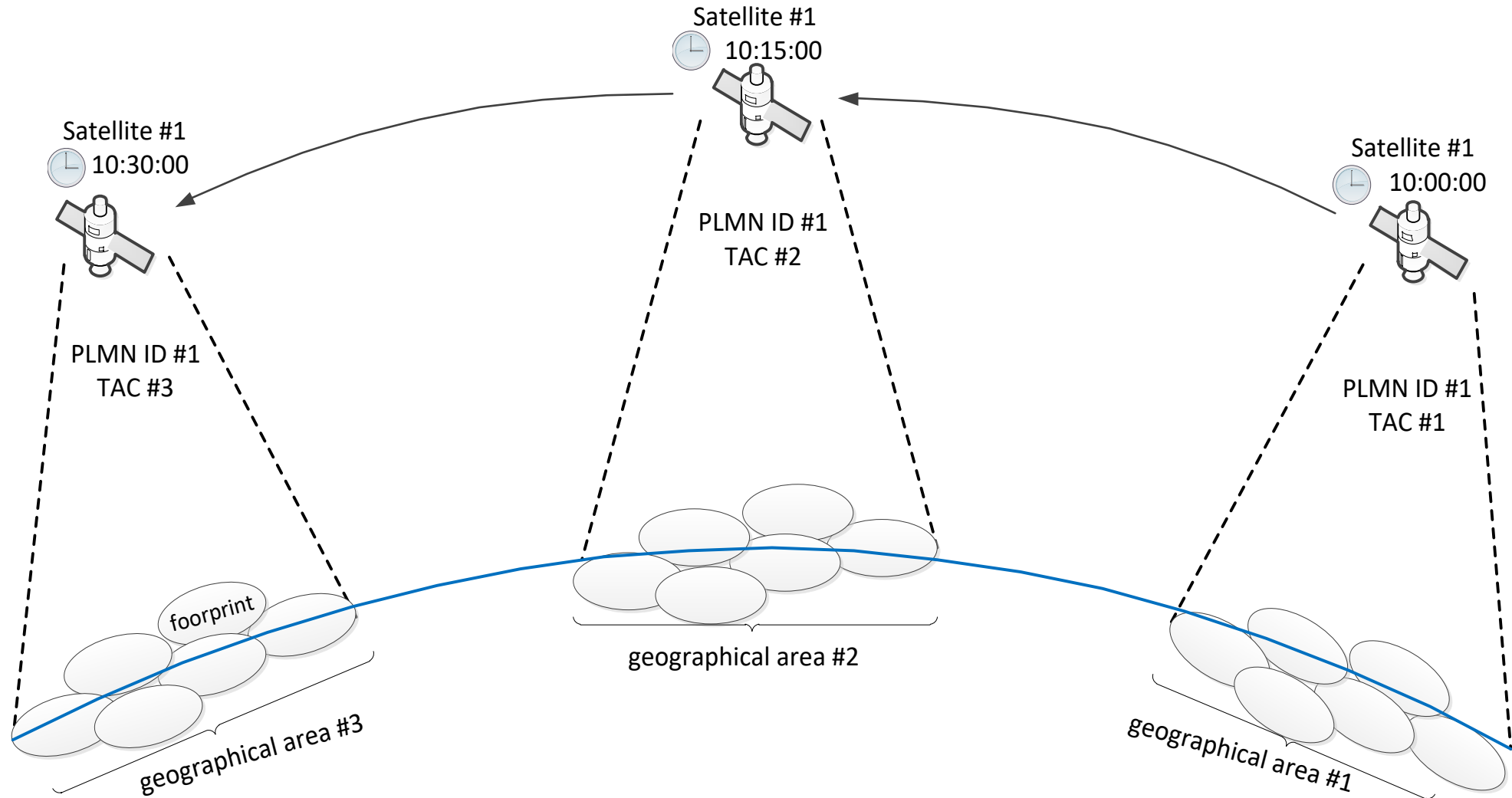
PLMN - public land mobile network is a combination of wireless communication services offered by a specific operator in a specific country (area).

› REGULATORY ASPECTS

- › 5G networks have to follow national/regional regulatory requirements
 - › Frequency licenses
 - › Mobile country code (MCC) / Mobile network code (MNC)
 - › Emergency calls
 - › Public warning service
 - › Lawful intercept
 - › Per country prohibition of satellite access
- › Satellite beams cover multiple countries, seas and oceans
- › In international waters: the UE can select a PLMN that uses the shared MCC (MCC=90x).

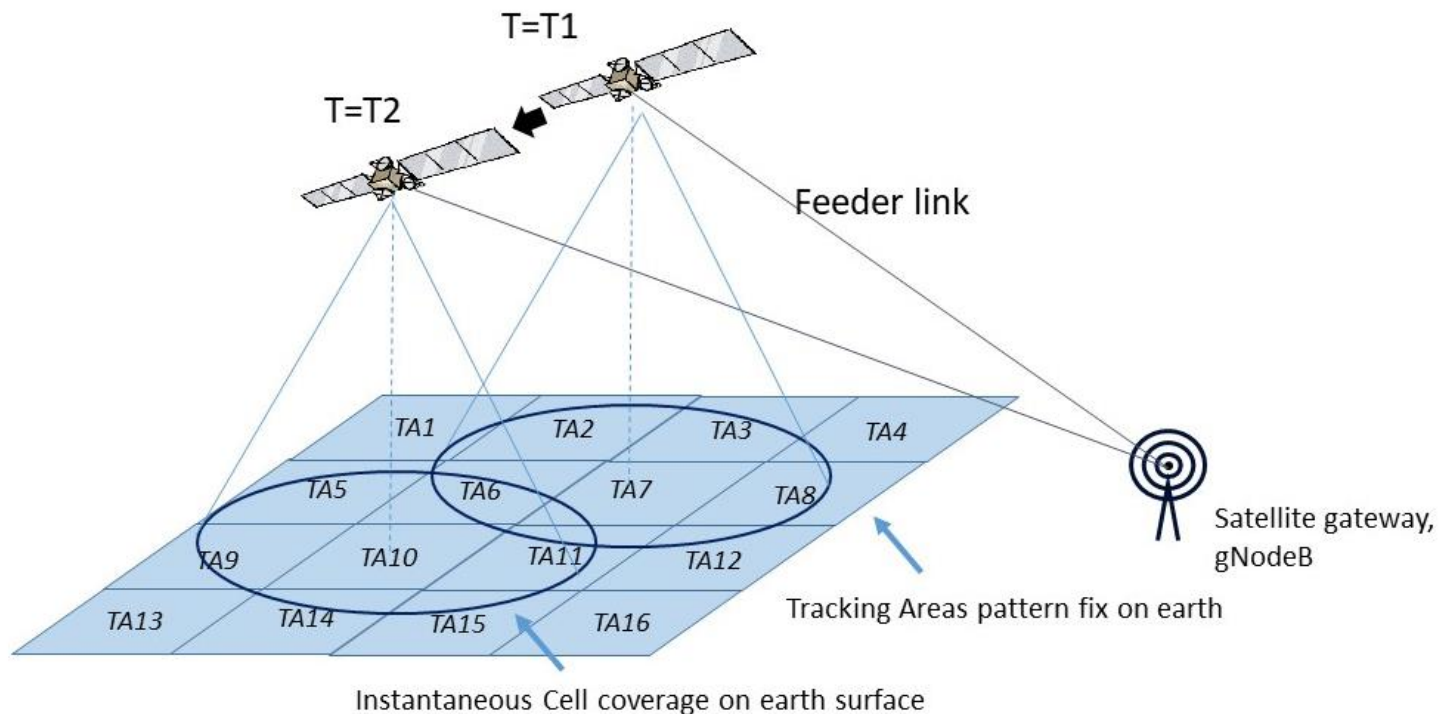


MOBILITY MANAGEMENT WITH MOVING SATELLITE COVERAGE AREAS (1)



MOBILITY MANAGEMENT WITH MOVING SATELLITE COVERAGE AREAS (2)

- Satellite where the radio beam cannot be steered - the cells/beams move across the earth surface along with the satellite. This category is referred to as earth-moving beams.



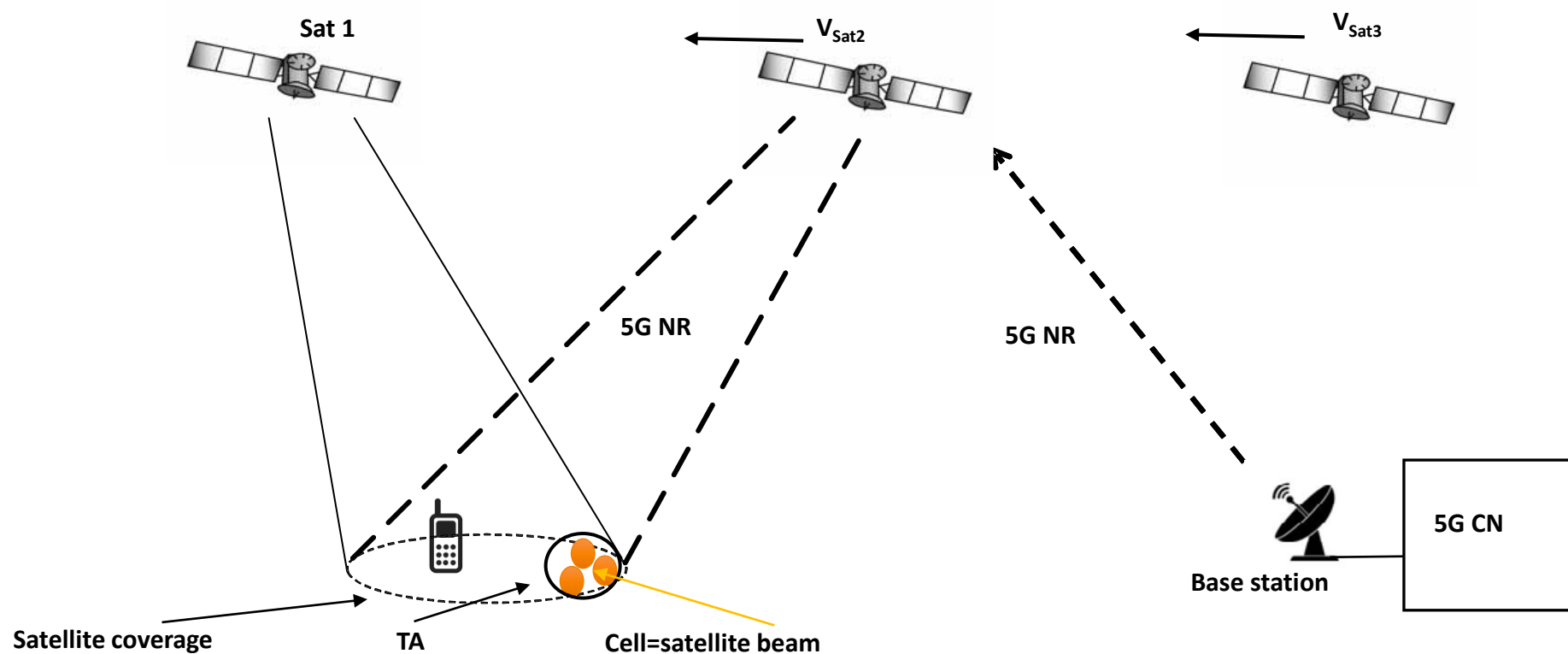
Following TACs will be broadcasted by the cell :

At time = T1	{TA1, TA2, TA3, TA4, TA6, TA7, TA8, TA11, TA12}
At time = T2	{TA5, TA6, TA7, TA9, TA10, TA11, TA14, TA15}

The RAN dynamically updates TAC list according the satellite motion.

› MOBILITY MANAGEMENT WITH MOVING SATELLITE COVERAGE AREAS (3)

- › High-end satellite with steerable beams – create earth-fixed cells/beams and TAs.



› 5G NEW RADIO ADAPTATION TO SUPPORT NTN

- › Large propagation delay
 - Synchronization: timing and frequency
 - Uplink timing alignment
 - HARQ – selectively enable/disable
- › Pronounced Doppler effect
 - Pre-compensation of Doppler shift
- › Random Access Channel
 - Extended acquisition window to cope high latency



› ONGOING INDUSTRY INITIATIVES

Madrid, 20 July 2022.- [Telefónica](#), through its divisions [Telefónica Tech](#) and [Telefónica Global Solutions \(TGS\)](#), and [Sateliot](#), a satellite telecommunications operator, are collaborating in the development of an innovative connectivity service with dual 5G NB-IoT technology in which Sateliot's new satellite network will be integrated with Telefónica Tech's current terrestrial NB-IoT networks to offer IoT connectivity wherever the customer needs it, including maritime coverage.

Samsung Electronics Introduces Standardized 5G NTN Modem Technology To Power Smartphone-Satellite Communication

Korea on February 23, 2023

ERICSSON, QUALCOMM AND THALES TO TAKE 5G INTO SPACE

| 11 JUL 2022 | [FRANCE](#) [5G](#) [SPACE](#)

MediaTek Powers World's First Satellite 5G NTN Smartphone Communication

MediaTek's collaboration with Rohde & Schwarz demonstrates the potential of 5G NTN technology to bring fast and reliable 5G connectivity everywhere via satellite

☉ Aug 16, 2022 - 9:00 PM

HSINCHU, Taiwan – August 16, 2022 – [MediaTek](#) reached a new 5G milestone by powering a smartphone with a 5G Non-Terrestrial Network (NTN) connection in a lab environment for the first time.

Highlights: JAN 5, 2023 | LAS VEGAS | Qualcomm products mentioned within this press release are offered by Qualcomm Technologies, Inc. and/or its subsidiaries.

- Qualcomm and Iridium entered into an agreement to bring satellite-based connectivity to next-generation premium Android smartphones; Garmin looks forward to collaborating with support for emergency messaging.

Snapdragon

Satellite is planned to support 5G Non-Terrestrial Networks (NTN), as NTN satellite infrastructure and constellations become available.

Nokia radio technology to enable AST SpaceMobile's direct-to-cell phone connectivity from space

- Nokia wins five-year global 4G and 5G deal from AST SpaceMobile
- AST SpaceMobile plans to bring cellular connectivity directly to 4G and 5G devices via low Earth-orbiting satellites in collaboration with mobile network operators
- Nokia and AST SpaceMobile committed to finding real-world solutions to expand universal coverage and close the digital divide around the world

28 July 2022

UN-CARRIER

T-Mobile Takes Coverage Above and Beyond With SpaceX

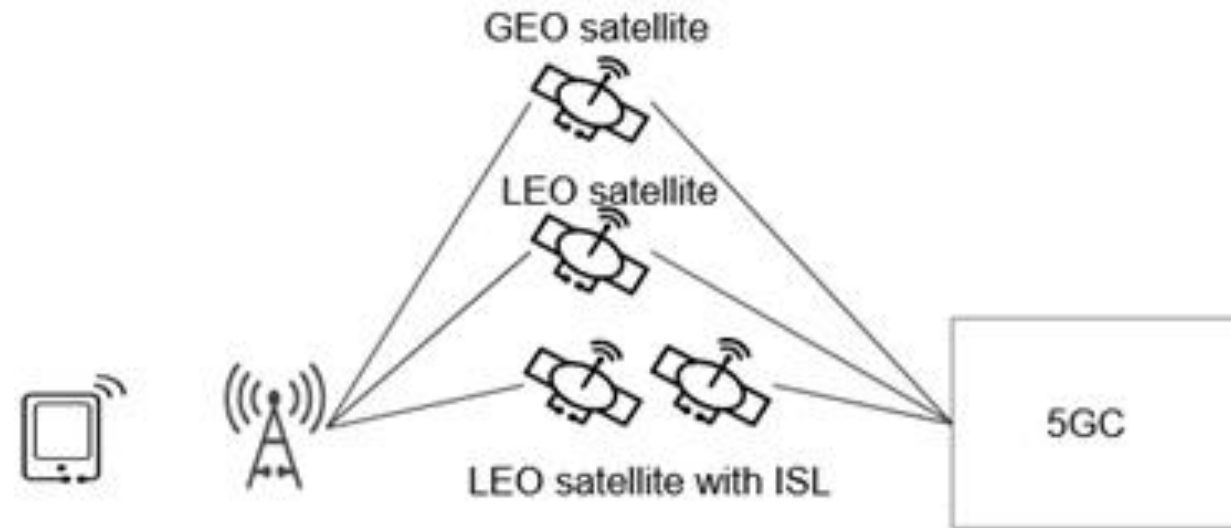
August 25, 2022

Companies share their vision to provide truly universal coverage, pairing SpaceX's breakthrough satellite constellation with T-Mobile's industry-leading wireless network

› 5G NTN STATUS

5G NTN developments:

- › 2018-2022: numerous 3GPP studies on integration of non-terrestrial networks in 5G (Release-15, Release-16)
- › 2022: 3GPP Release-17 standard includes 5G NTN specification (transparent satellites)
- › 2023: Release-18 includes 5G NTN enhancements (discontinuous coverage)
- › 2023: Release-18 5G Satellite Backhaul with:
 - › Dynamically changing latency and data rates
 - › Edge Computing on board GEO satellite
- › Target service opening dates:
 - › 5G IoT NTN direct connectivity (2024-2025);
 - › 5G NTN direct connectivity (2025-2030);

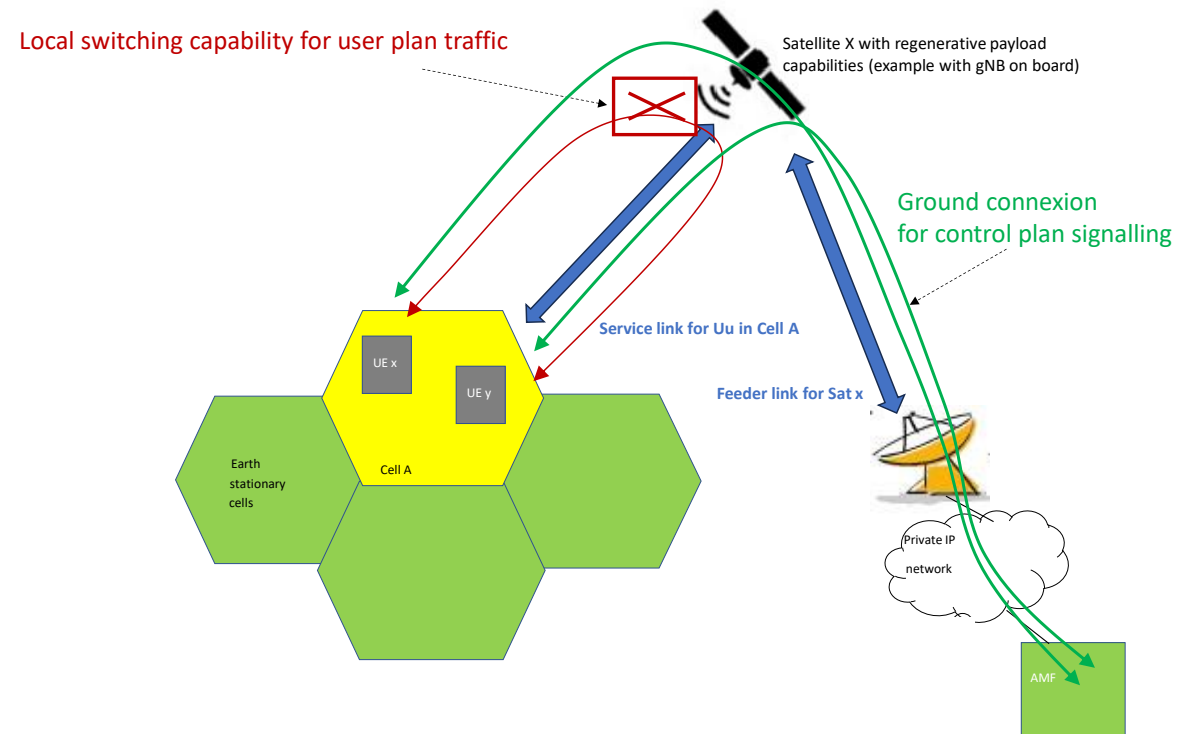


3GPP TR 23.700-27: Example scenario that gNB has multiple candidate satellite backhauls

› 5G NTN WAY FORWARD

- › 2024: Release-19 Study on integration of satellite components in the 5G architecture
 - › Regenerative payload architecture with gNB onboard satellite
 - › Support of UE-satellite-UE communication
 - › Store and Forward operation
 - › Application enablement for Satellite access enabled 5G Services
 - › 5G NTN indirect network relaying (e.g. via Vehicle Mounted Relay above 10GHz)

- › Research towards 6G TN-NTN unification



Basic concept of UEs- SAT- UEs communications on LEO satellite in same cell without ISL
Source Thales, TR 23.700-29

3GPP 5G NTN STANDARD: OVERVIEW OF REPORTS AND SPECIFICATIONS

Release-15:

TR 38.811: Study on New Radio (NR) to support Non Terrestrial Networks (Release 15), 2018

Release-16:

TR 22.822: Study on using Satellite Access in 5G; Stage 1, 2018

TR 38.821: Solutions for NR to support non-terrestrial networks (NTN), 2019

TS 22.261: Service requirements for the 5G system; Stage 1, 2018

TR 23.737: Study on architecture aspects for using satellite access in 5G, 2020

TR 28.808: Study on management and orchestration aspects of integrated satellite component in a 5G network, 2021

Release-17:

TR 24.821: Study on PLMN selection for satellite access, 2021

TR 36.763: Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN), 2021

TR 24.821: Study on PLMN selection for satellite access, 2021

TR 23.700-Integration of satellite systems in the 5G architecture

Release-18:

TR 22.926: Guidelines for extra-territorial 5G Systems (5GS), 2021

TR 38.882: New SID: Study on requirements and use cases for network verified UE location for NTN in NR, 2022

TR 23.700-28: 5GC enhancement for satellite access Phase 2, 2023

TR 23.700-27: Study on satellite backhauling, 2023

TR 23.700-71: Enhanced location services, 2023

TR 33.700-28: Study on security aspects of satellite access, 2023

Release-19:

TR 22.865: Study on satellite access – Phase 3, 2023

TR 22.841: Study on upper layer traffic steering, switchin and splitting over dual 3GPP access, 2023

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