



**TNO** innovation  
for life

# 5G NON-TERRESTRIAL NETWORKS

**DUTCH GUILD SATCOM WORKSHOP**

APRIL 24, 2024

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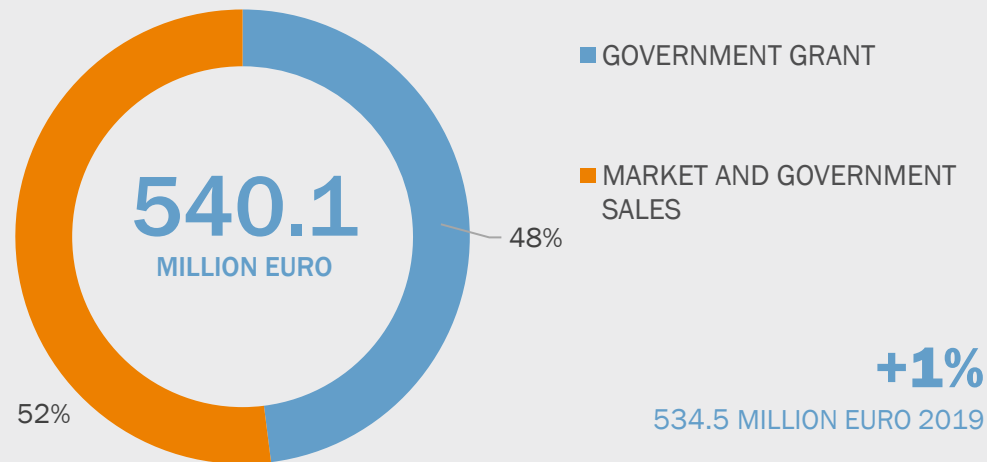
# › **OVERVIEW**

- › TNO in a nutshell
- › 3GPP
- › Satcom role in 5G
- › 5G non terrestrial networks (5G NTN) – topologies and architectures
- › 5G NTN status and way forward towards 6G

# TNO

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

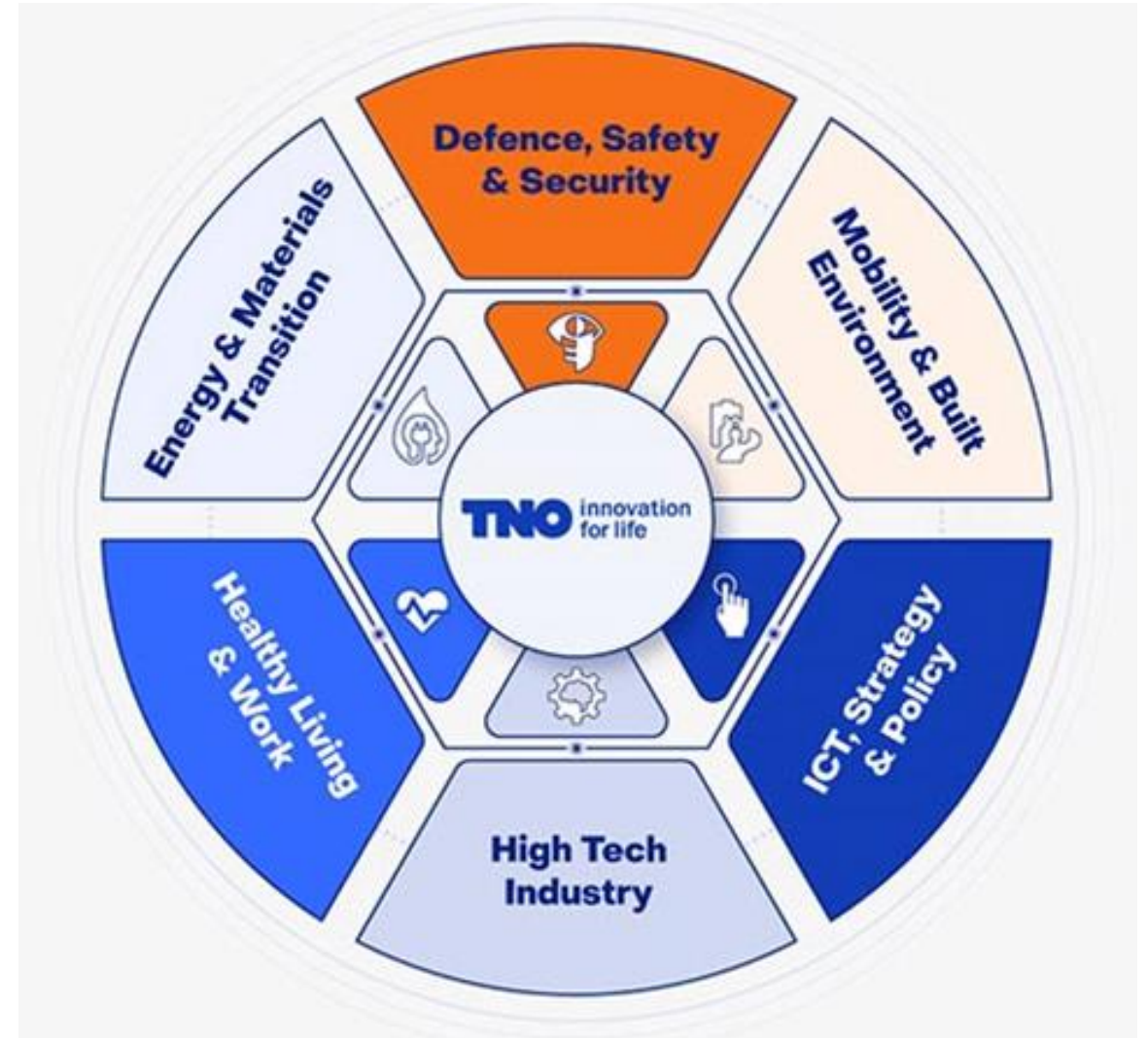
## REVENUE ORGANISATION TNO (INCL. GOVERNMENT GRANT)



## 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

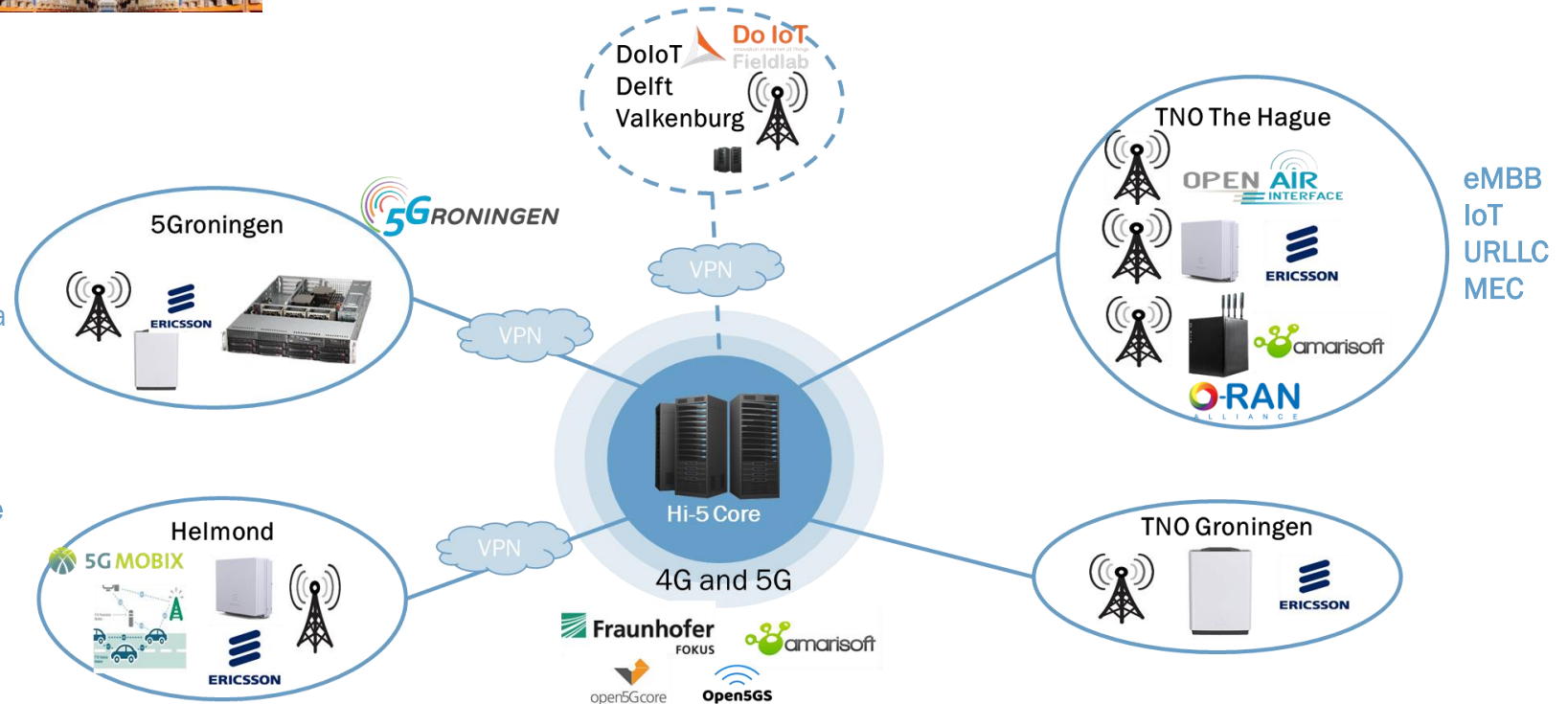
- XR Collaborative Maintenance
- Ambulance with remote medical support (video, medical imaging via ultrasound probe)

### 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

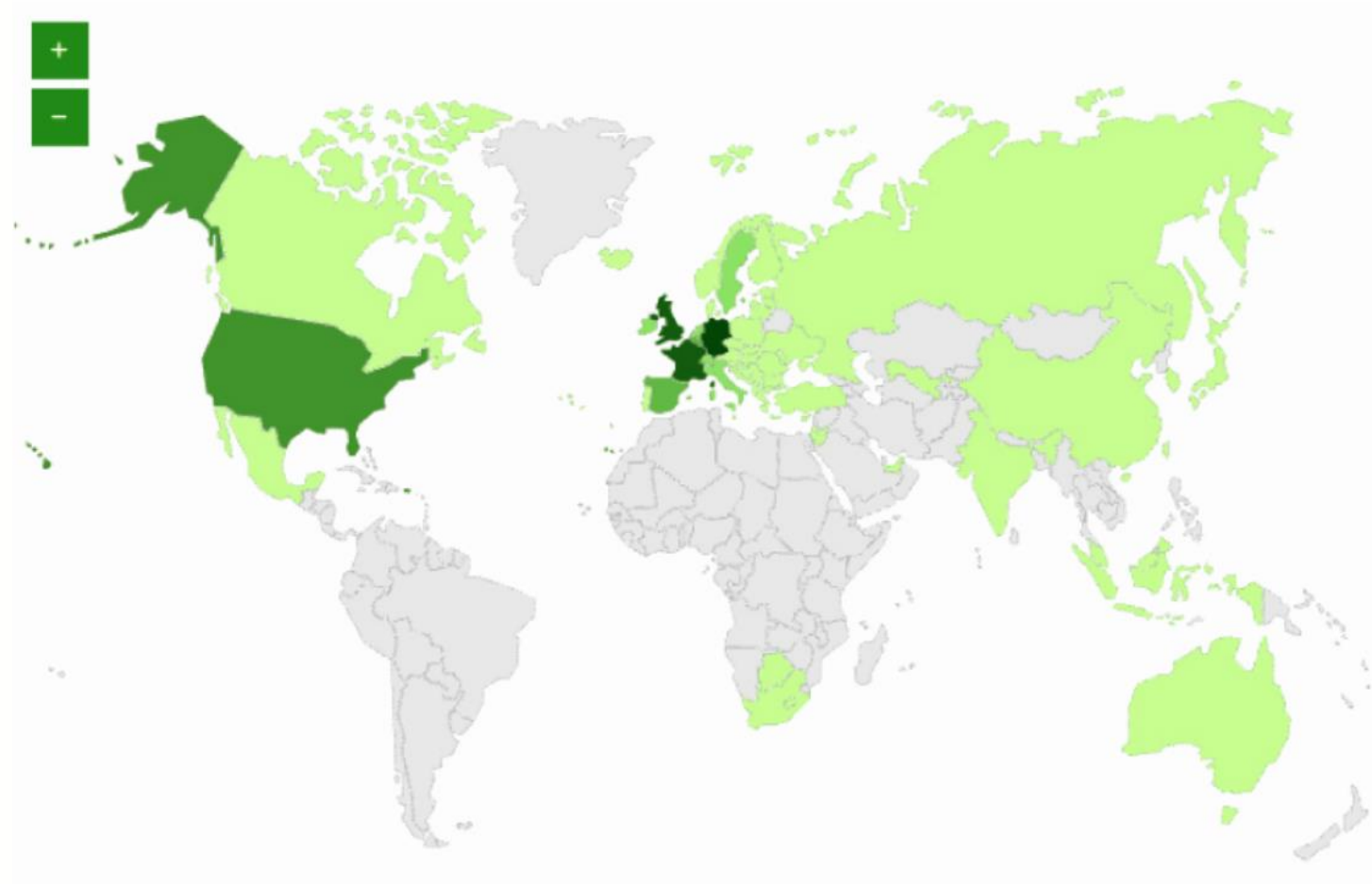


**930**  
Members

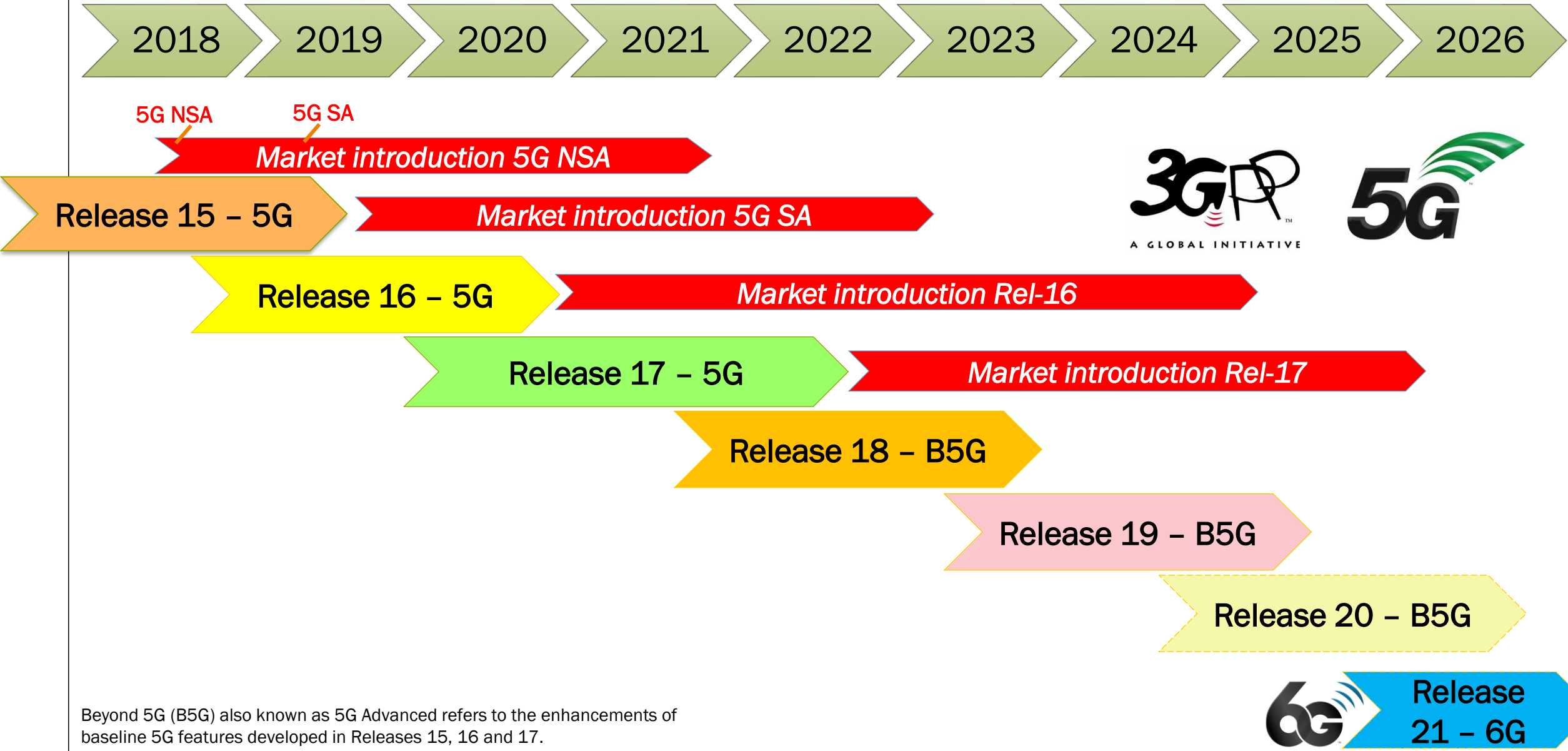
**61**  
Countries

**50**  
Standardization Groups

**52312**  
Standards Published



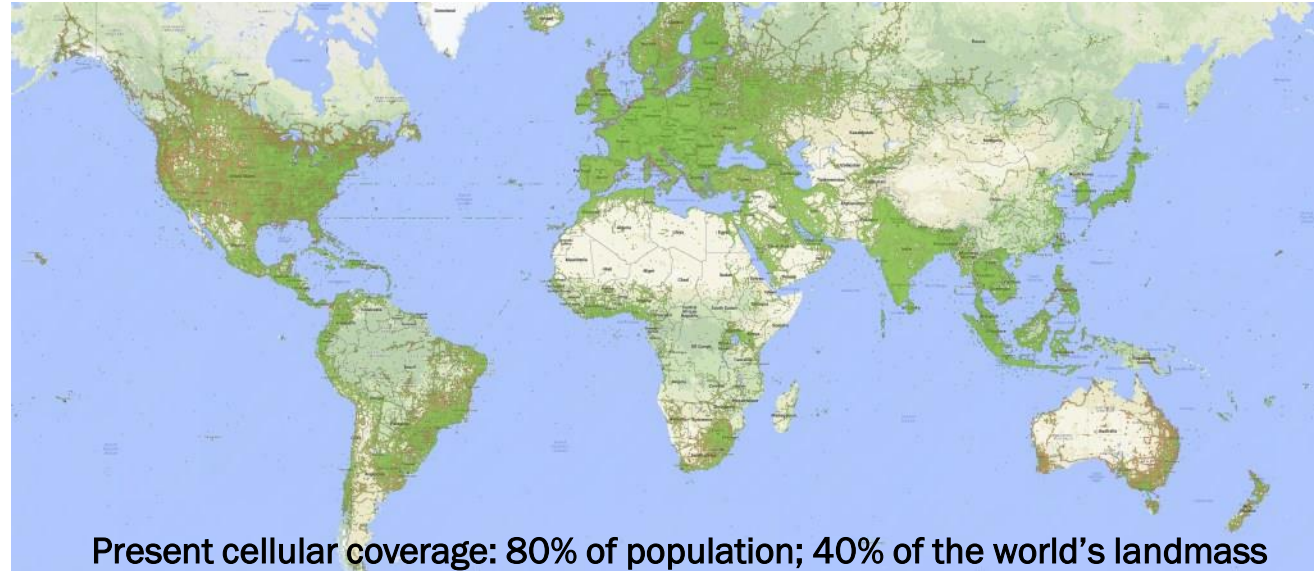
# 5G STANDARDS: 3GPP MULTI RELEASE TIME PLAN



Beyond 5G (B5G) also known as 5G Advanced refers to the enhancements of baseline 5G features developed in Releases 15, 16 and 17.

## › 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.

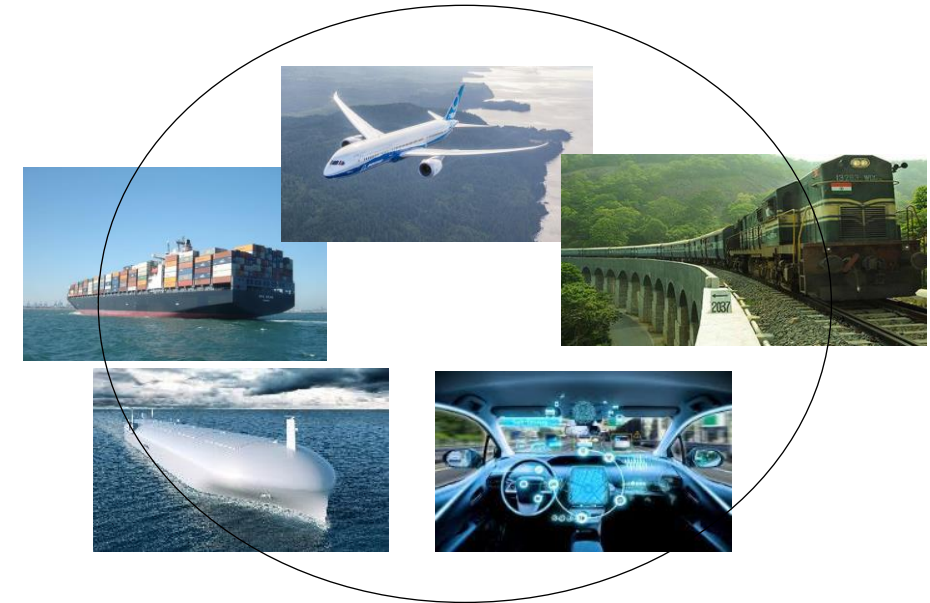
# › 5G NTN USE CASES



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

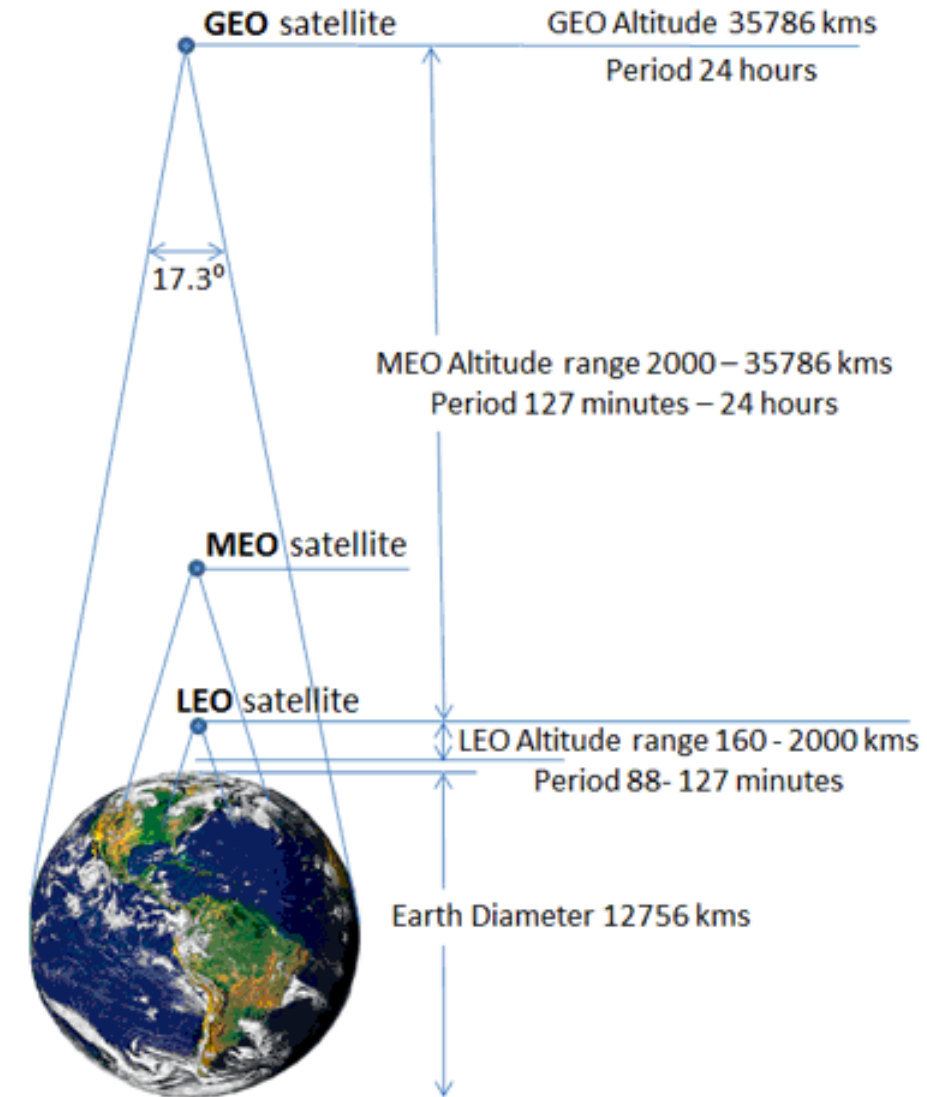


## › NTN PLATFORM TYPES

- › Non-terrestrial networks (NTN) include LEO, MEO, GEO satellites

Satellite	Altitude range [km]	Orbit	Beam footprint size [km]	Delay [ms] ground to satellite
Low-Earth Orbit (LEO)	300 - 1500	Circular around the earth	50 - 1000	>4
Geostationary Earth Orbit (GEO)	35 786	Fixed position	200 - 3500	135

## Satellite Orbits, Periods and Footprints



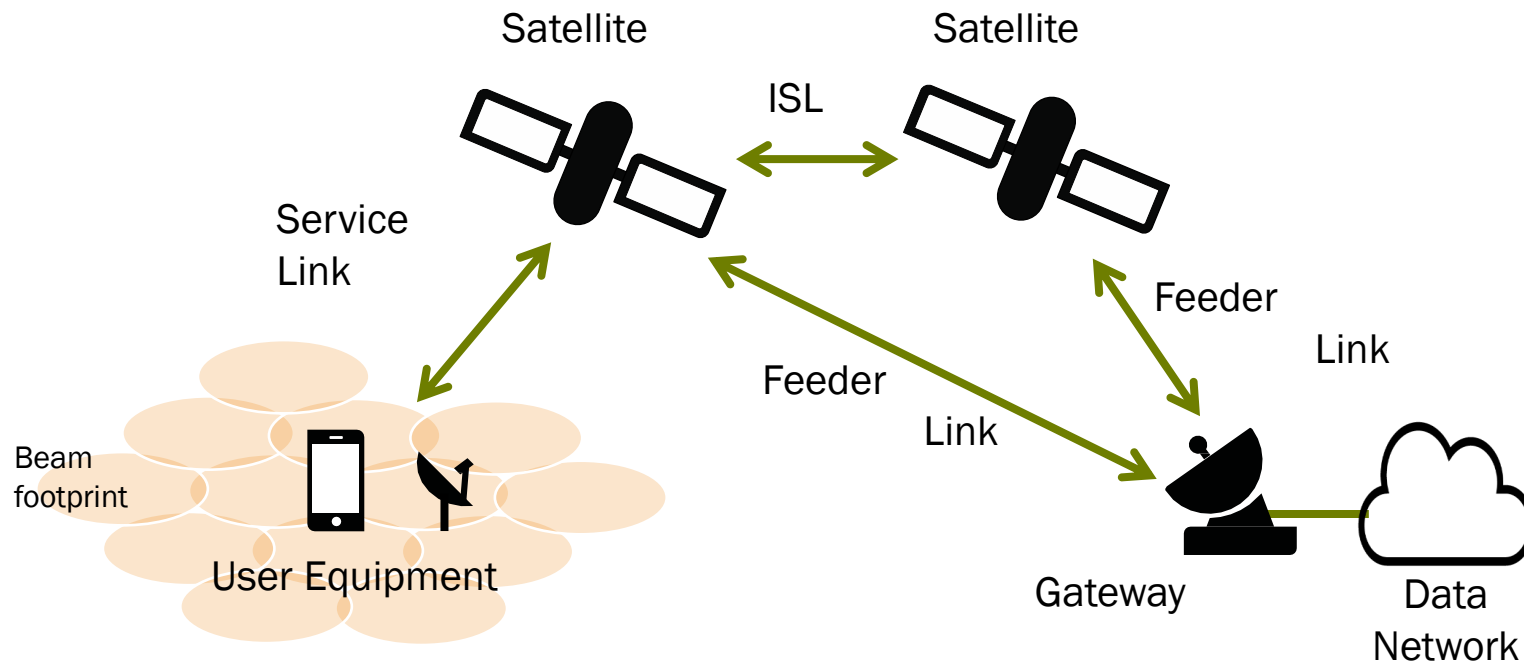
Source: 3GPP TR 38.811 and TR 38.821 Study on New Radio (NR) to support non-terrestrial networks

## 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:

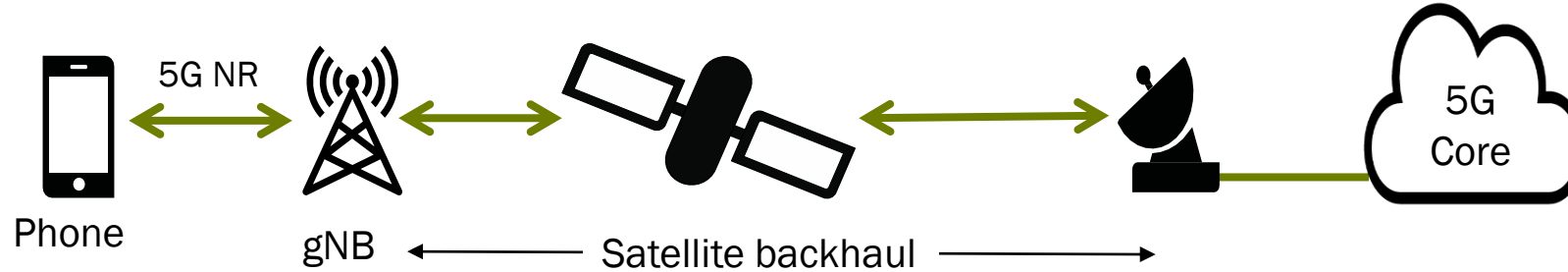
- 1) - 3) and
- 4) Signal demodulation/modulation
- 5) Adaptive routing (ISL)



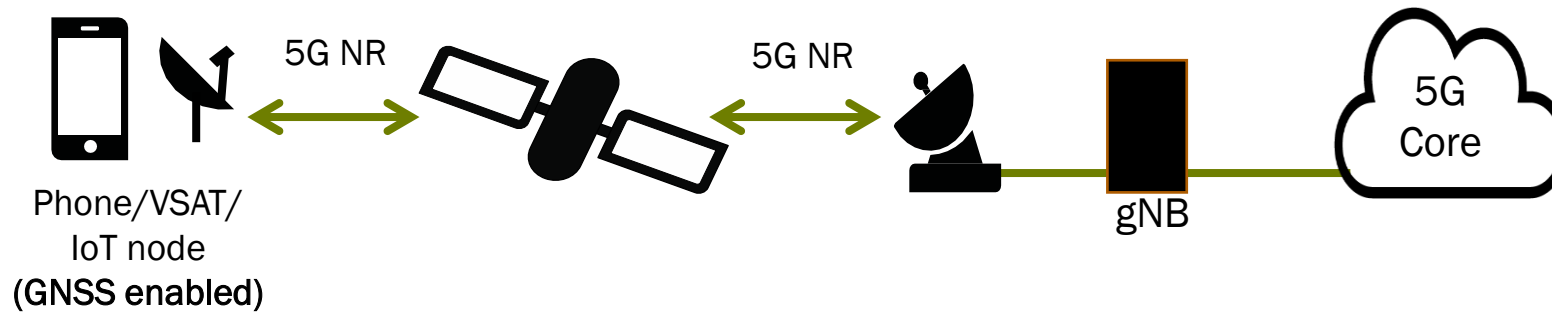
Increased system flexibility, signal quality and capacity.

# 5G NTN SCENARIOS

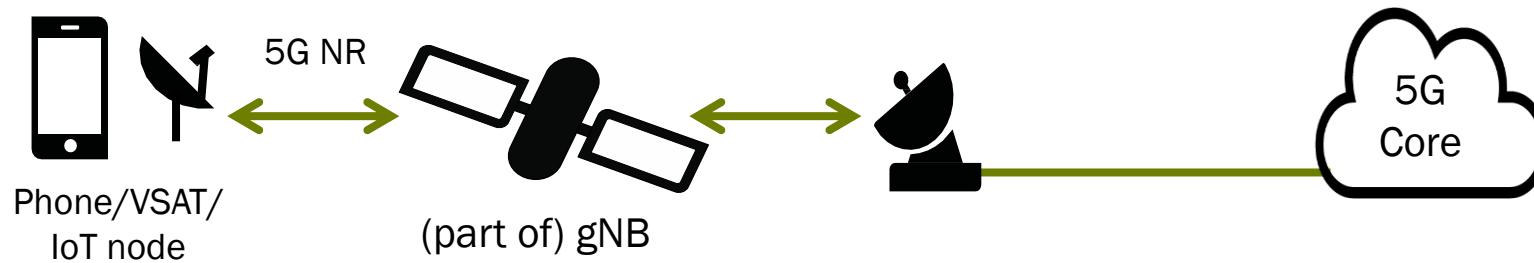
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Satellite backhaul to a remote 5G base station (gNB).



Transparent satellite (direct access)  
Rel-17, Rel-18

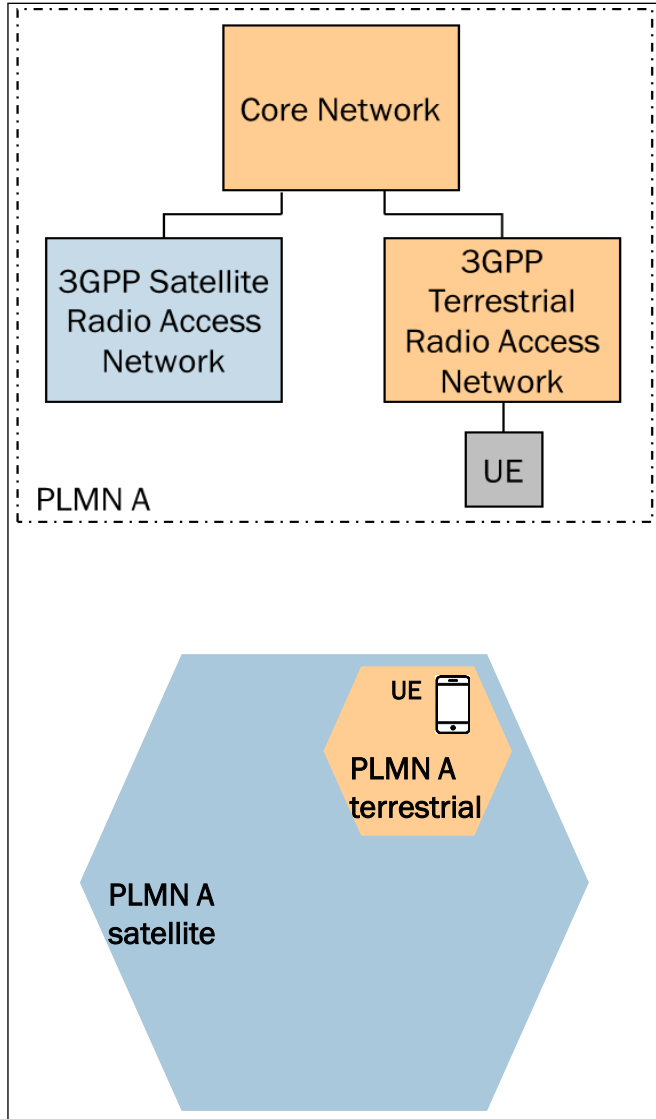


Regenerative satellite (direct access)  
Rel-19 ongoing

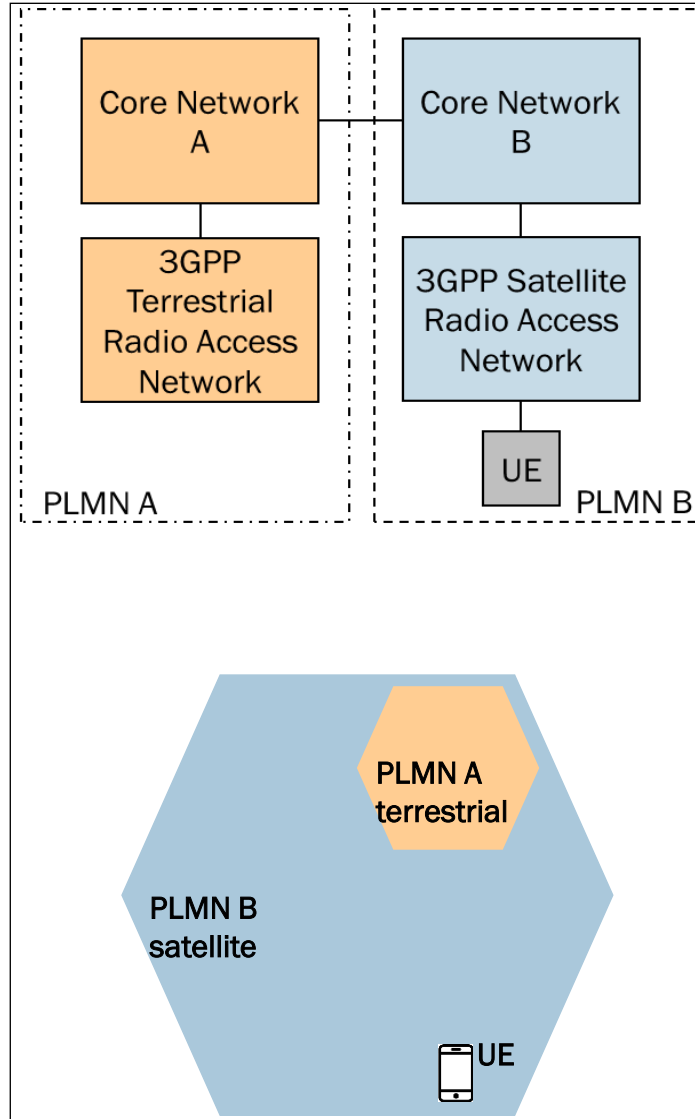
Agreed approach: Integrate satellite in 5G with minimal impact on User Equipment and Network Infrastructure!

# 5G TN-NTN INTEGRATION SCENARIOS

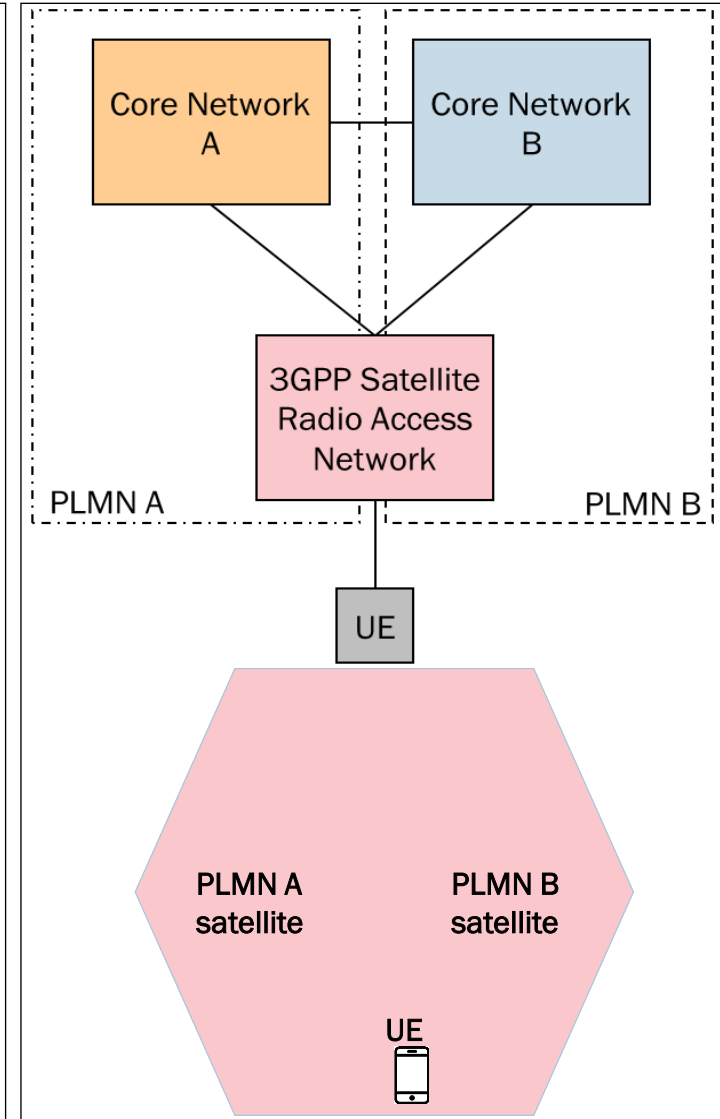
NTN access within a PLMN



Roaming between TN and NTN



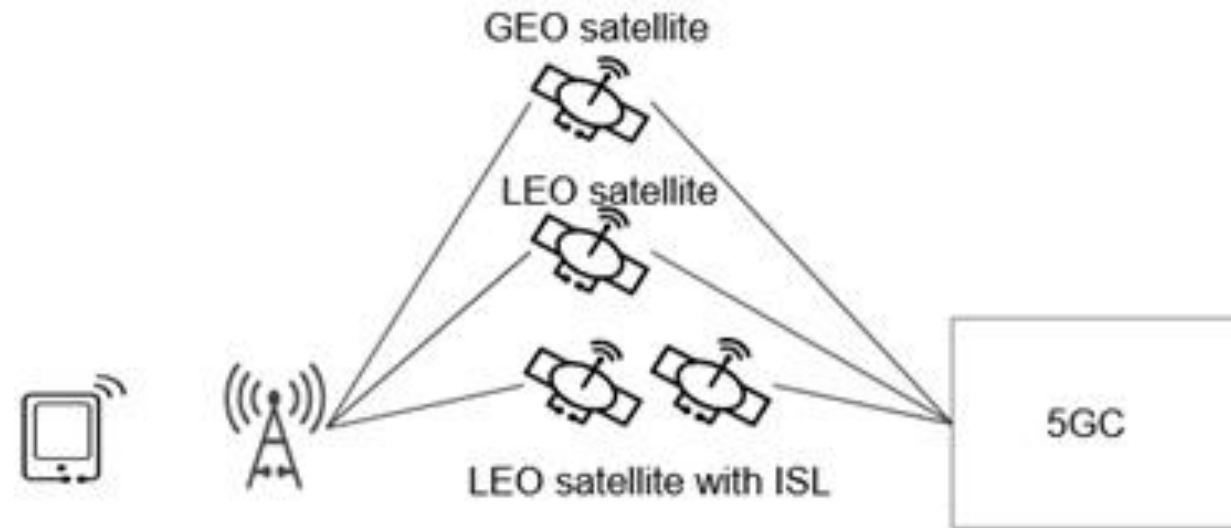
Shared NTN access



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

## › 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*
- › Expected service opening dates:
  - › 5G IoT NTN and messaging (2024-2025);
  - › 5G NTN (2025-2030);



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

# › 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

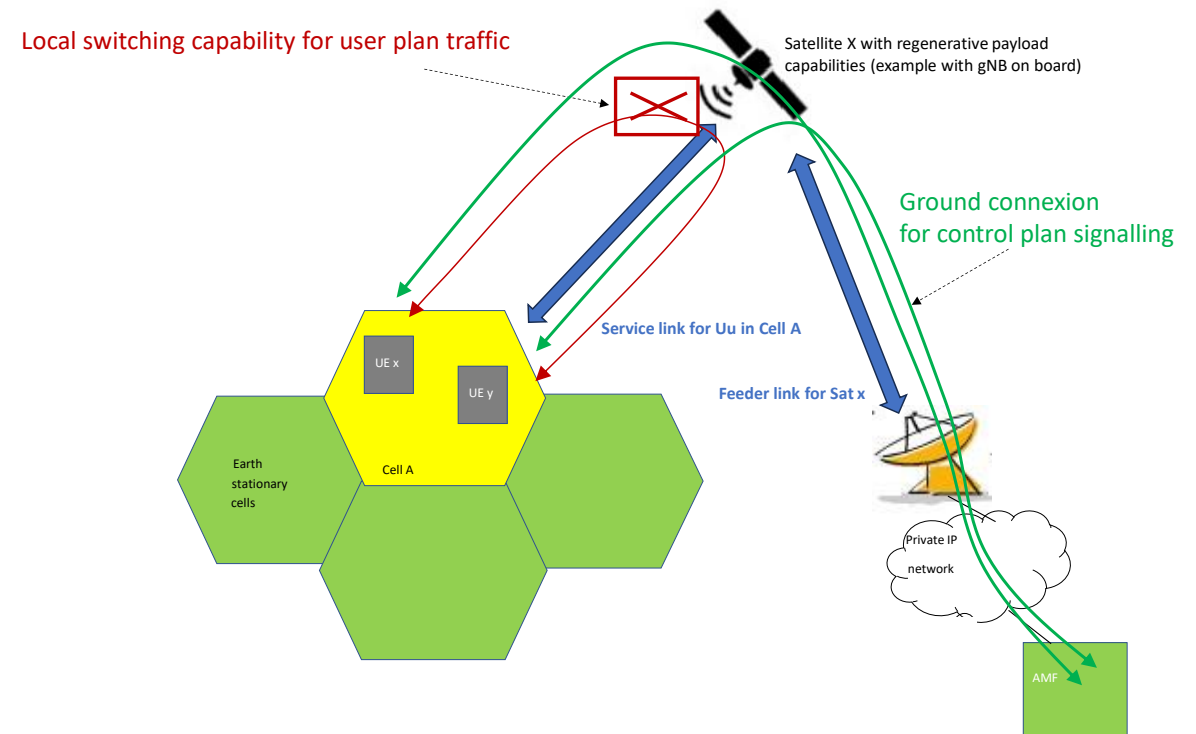
## T-Mobile Takes Coverage Above and Beyond With SpaceX

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 ONGOING STANDARDIZATION ACTIVITIES

- › 2024-2025: Release-19 Study on integration of satellite components in the 5G architecture (TR 23.700-29)
  - › Regenerative payload architecture with gNB onboard satellite; UPF + Edge onboard
  - › Support of UE-satellite-UE communication
  - › Store and Forward operation
  - › 5G NTN indirect network relaying (e.g. via Vehicle Mounted Relay above 10GHz)

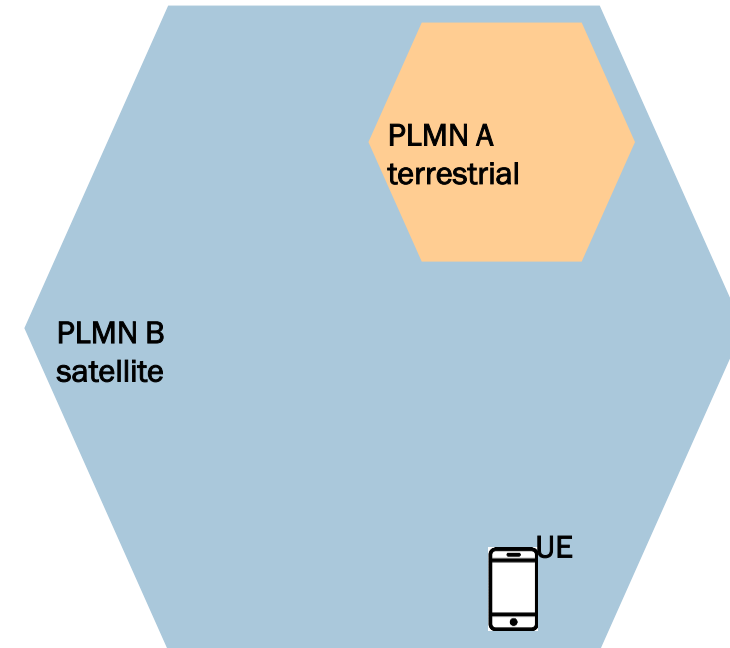


Basic concept of UEs- SAT- UEs communications on LEO satellite in same cell without ISL  
Source Thales, TR 23.700-29



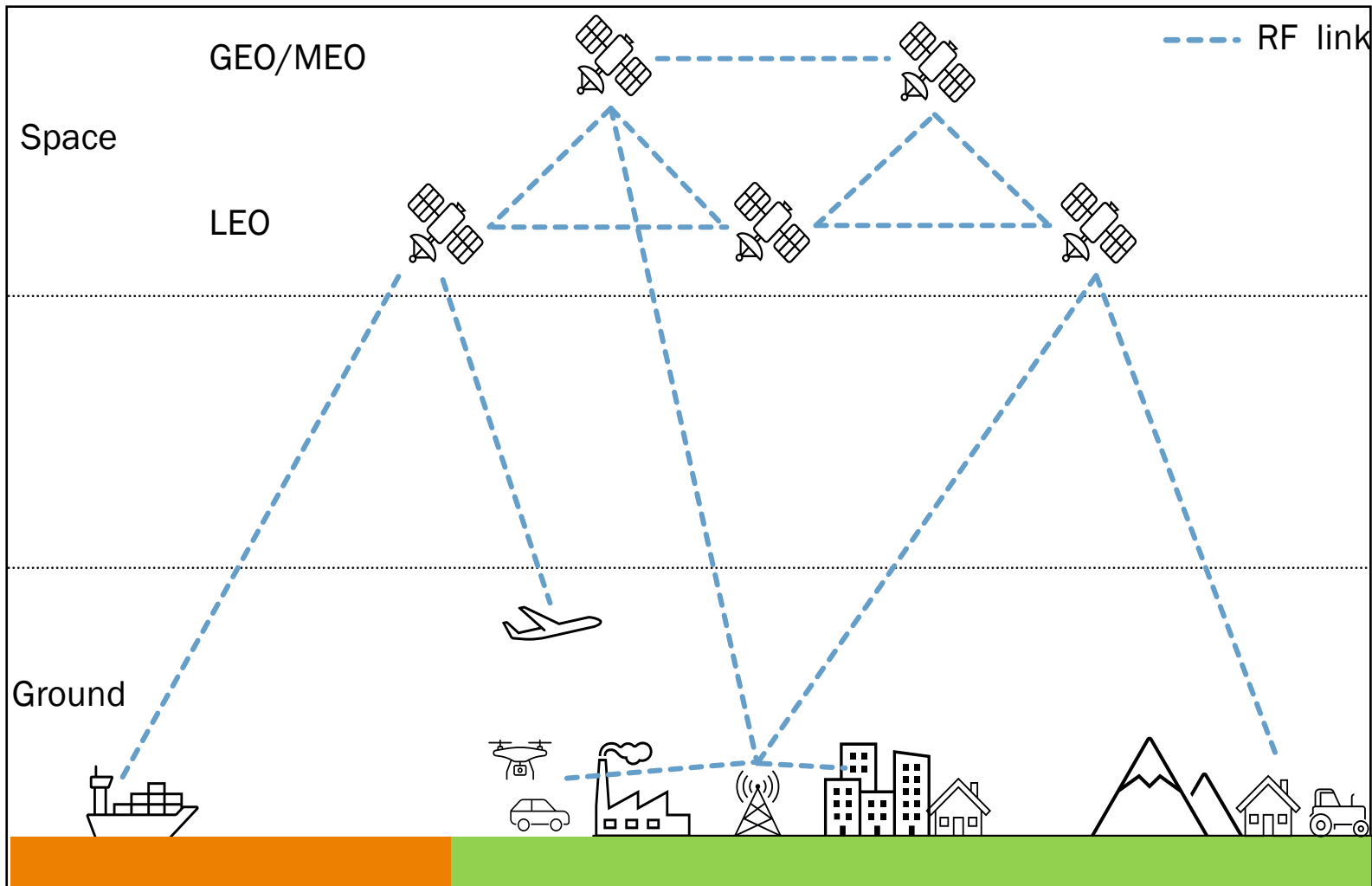
## › MULTICAST AND BROADCAST SERVICES (MBS)

- › Release-17 standardized MBS over 5G terrestrial networks (TN)\*
- › Satellite companies interested to conduct a study on MBS over NTN
- › Motivation for MBS over NTN 3GPP study:
  - › Broadcast services: 50% satellite operators revenue (now DVB-S based)
  - › NTN MBS would enable evolution of satellite operators broadcast services
  - › 3GPP NTN for media content distribution to large geographical areas
  - › MNOs could offload MBS traffic from terrestrial networks
- › Envisaged MBS NTN use-cases
  - › Broadcast Live TV Distribution using a joint TN/NTN deployment
  - › Reliable multicast in joint TN/NTN deployments (content distribution to edge caches)
  - › Mode of operation: Free-to-Air (SIM-card less support), SIM-Card support
  - › User types: Mobile User in large/medium/small vehicles and Fixed User indoor
- › **No consensus** to proceed with MBS NTN study in Rel-20 → possibly to be moved to 6G phase



# › 5G TN-NTN INTEGRATION

- › 5G NTN (Rel-17, Rel-18) transparent satellites
- › B5G NTN (Rel-19, Rel-20) – satellites with regenerative payload
- › Dominance of RF communications



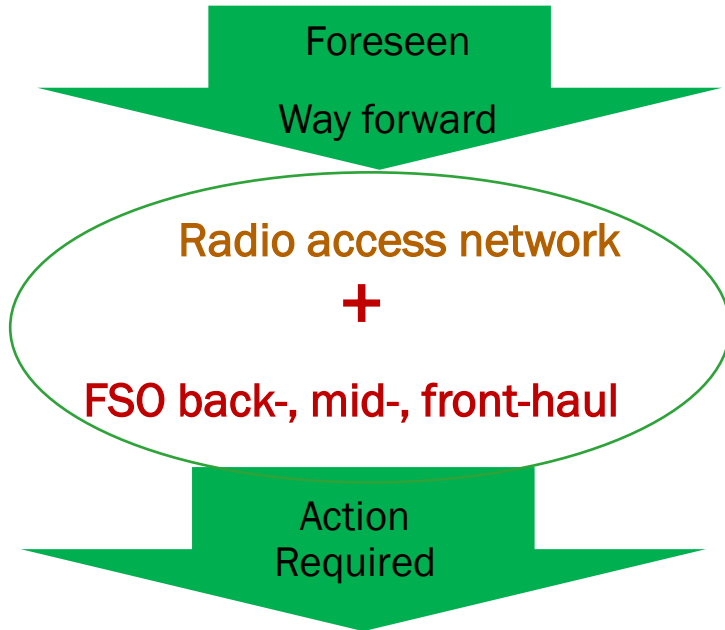
# › TOWARDS 6G TN-NTN UNIFICATION

6G towards:

- › 100x improvement of target KPIs compared to 5G
- › Multilayer (terrestrial, airborne, spaceborne) networking
- › Global coverage

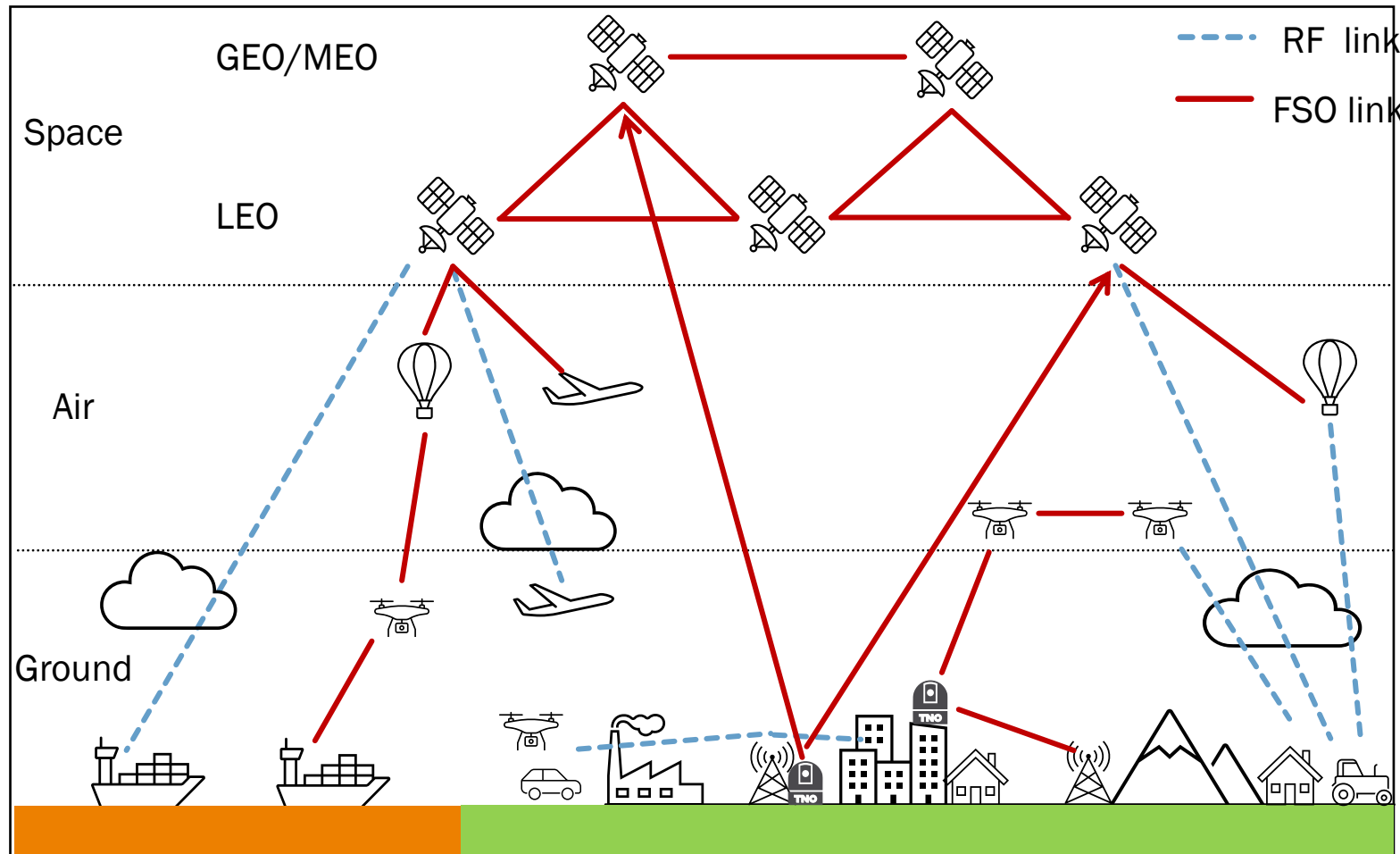
KPI	Foreseen 6G target
Experienced DR	~ x10Gpbs
Peak DR	~ x100Gpbs
Connection density	~10 <sup>8</sup> /km

Eternal challenge - spectral scarcity!



- Standardization of Free Space Optical FSO (laser) communications

- FSO - 3GPP standard interoperability



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# 3GPP 5G NTN STANDARD: OVERVIEW OF REPORTS AND SPECIFICATIONS IN 3GPP SYSTEM ARCHITECTURE WORKING GROUP

## **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

# OVERVIEW OF DIRECT TO DEVICE SERVICES IN 2023

Emergence of direct to device 3GPP based services in 2023:

Operator	Satellite system (deployed)	Spectrum	Technology	Operational	Services
Dedicated providers					
Space X	2016 LEO (0)	MNO spectrum/ 2GHz MSS	Pre Rel-17 3GPP	2024	Messaging, speech, broadband
AST SpaceMobile	243 LEO (1)	MNO spectrum	Pre Rel-17 3GPP	2024	Messaging, speech, broadband
Lynk	5000 LEO (3)	MNO spectrum	Pre Rel-17 3GPP	2Q2023	Messaging, LDR (low- data rate)
Sateliot	250 LEO (1)	2.0GHz MSS	Rel-17 NB-IoT (NB-NTN)	TBD	NB-IoT
Iridium	66 LEO	L-band	Proprietary	Yes	LDR/Messaging
Orbcomm	31 LEO	137-150 MHz	Proprietary	Yes	Assets tracking
GlobalStar	24 LEO	L/S-band	Proprietary	Yes	Assets tracking
Ligado	1 GEO	L-band	Rel-17 NB-IoT (NB-NTN)	TBD	NB-IoT

Source: <https://www.5gamericas.org/update-on-5g-non-terrestrial-networks/>

# OVERVIEW OF PARTNERSHIP TRIALS IN 2023

Overview of partnership trials that also involve 5G-NTN (3GPP based) solutions:

Partnerships					
T-Mobile/SpaceX	2016 LEO (0)	MNO spectrum	3GPP-Rel 12	2024	Messaging, Data, Voice, Video
AT&T/AST	243 LEO (0)	MNO spectrum	3GPP-Rel 12	2024	Messaging, Data, Voice, Video
Verizon/Kuiper	3236 (0)	Ka band	Proprietary	TBD	Ground sites backhaul - LTE and 5G
Apple/Globalstar	24 LEO	L-band, S-band	Proprietary	4Q2022	Emergency Messaging
Qualcomm/Iridium	66 LEO	L-band	Proprietary	4H2023	Messaging
Mediatek/Skylo/Bullitt	6 GEO (Inmarsat)	L-band	3GPP-NTN	1Q2023	Messaging
Skylo/Ligado/Viasat	1 GEO (Ligado)	L-band	3GPP-NTN	2H2023	NB-IoT, Messaging, LDR