IoT for Earth Observation Workshop - ESTEC (ESA)

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01

# Who we are

A Fully standard compliant Solution

- Sateliot is a **5G NB-IoT NTN (Rel. 17) Coverage Extension** satellite operator in SSO Low Earth Orbit for **wholesale** service to **MNO** (NB-IoT Coverage Extension).

- Vertical agnostic Scalable Network architecture.

- Fully compliant with 3GPP Rel. 17.
  - First approach with Small Satellite in LEO (form factor CubeSat for example) constrained in antenna and PA (TR 36.763 Set-4).

- Enhanced with global service without continuous connection to the ground segment network, it means regenerative satellites, disruption in the feedlink and innovative **Store&Forward** approach in the 3GPP architecture.
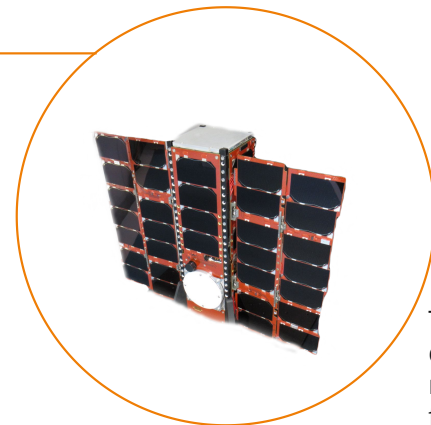

Member of 3GPP since 2019 being, among space companies, the major contributor to the Rel. 17 IoT NTN Study Item.

5G NB-IoT NTN coverage extension concept

IoT cellular tower from space
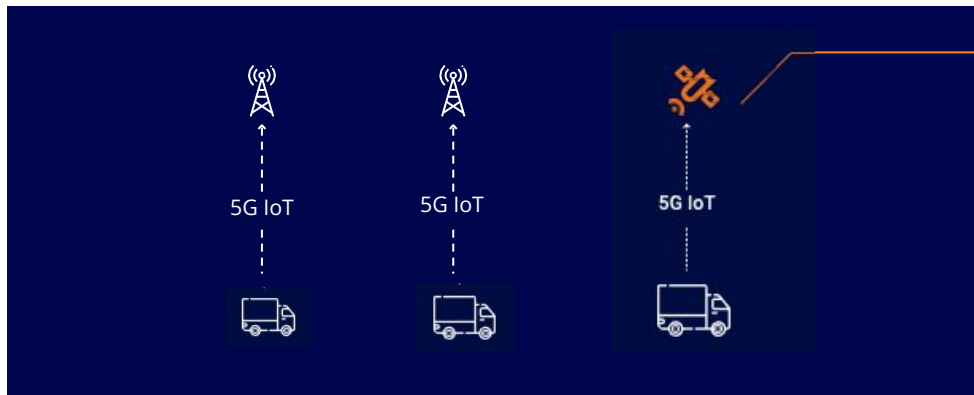
👍 Zero equipment cost for the final customer

👍 Zero investment cost for the Mobile Operator

👍 Scalable business model with global mobile operators

This picture does not represent the final satellite image

Sateliot
Enables universal and global IoT connectivity

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Contribution to the 5G IoT standard during the study item

#1 contributor from space industry

Mediatek	60
Ericsson	53
Huawei	50
Nokia	49
Zte	49
Hisilicon	48
Qualcomm	48
Thales	48
Oppo	46
Xiaomi	43
Cmcc	41
Samsung	39
Catt	36
Apple	32
Lenovo	31
Motorola	31
Nec	30
Sony	28
Intel	27
Interdigital	27
Spreadtrum	27
Asia Pacific Telecom	22
Sanechips	22
Fgi	21

Sateliot	**17**
Gatehouse	**16**
Lg	16
Itri	15
Eutelsat	**14**
Panasonic	14
Iii	13
Convida Wireless	11
Echostar	**11**
Esa	11
Fraunhofer	11
Caict	10
Inmarsat	**10**
Vivo	10
Asus	7
Etri	7
Vodafone	7
99 Error	6
Intelsat	**6**
Kepler	**6**
Novamint	6
British Telecom	5
Chairman	5
Ligado	**5**

Omnispace	**5**
Zhejiang Lab	5
Bupt	4
Ntt Docomo	4
Sequans	4
Tno	4
Avanti	**3**
Ct1	3
Hispasat	**3**
Kt	3
Lockheed Martin	3
Cewit	2
Itl	2
Mitsubishi	2
Moderator Ericsson	2
Moderator Mediatek	2
Moderator Thales	2
Moderator Zte	2
Rakuten	2
Reliance	2
Turkcell	2
Acer	1
Chairman Ericsson	1
Chairman Mediatek	1

Chairman NOKIA	1
Chairman QUALCOMM	1
Coordinator MCC	1
DEUTSCHE TELEKOM	1
EDF	1
ESOA	1
IITH	1
IITM	1
MAGISTER	1
MAVENIR	1
Moderator EUTELSAT	1
Moderator NOKIA	1
Moderator QUALCOMM	1
Moderator SAMSUNG	1
NCCUNTU	1
NOMOR	1
OQ	**1**
PHILIPS	1
SAANKHYA LABS	1
SHARP	1
SIERRA WIRELESS	1
SOFTBANK	1
TELECOM ITALIA	1
UNIBO	1

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02

3GPP NB-IoT NTN Standard

Who is the 3GPP

Technical Specification Groups (TSGs)

TSG CT Core
Network & Terminals

- **CT WG1**
  User Equipment to Core Network protocols

- **CT WG3**
  Interworking with External Networks & Policy and Charging Control

- **CT WG4**
  Core Network Protocols

- **CT WG6**
  Smart Card Application Aspects

TSG RAN
Radio Access Network

- **RAN WG1**
  Radio Layer 1 (Physical Layer)

- **RAN WG2**
  Radio Layer 2 and Radio Layer 3 (Radio Resource Control)

- **RAN WG3**
  UTRAN/E-UTRAN/NG-RAN architecture and related network interfaces

- **RAN WG4**
  Radio Performance and Protocol Aspects

- **RAN WG5**
  Mobile terminal conformance testing

- **RAN AH1**
  ITU-R Ad Hoc

TSG SA
Service & System Aspects

- **SA WG1**
  Services

- **SA WG2**
  System Architecture and Services

- **SA WG3**
  Security and Privacy

- **SA WG4**
  Multimedia Codecs, Systems and Services

- **SA WG5**
  Management, Orchestration and Charging

- **SA WG6**
  Application Enablement and Critical Communication Applications

Source: https://www.3gpp.org/3gpp-groups

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Who is the 3GPP

- 3GPP is a collaborative agreement between Standards Development Organizations (SDOs) and other related bodies for the production of a complete set of globally applicable Technical Specifications and Reports for mobile communications systems

- Established in 1998 to produce the specifications of the UMTS standard in the context of 3G systems

- Currently in charge of the development and maintenance of the specifications for GSM (2G), UMTS (3G), LTE (4G) and 5G systems

http://www.3gpp.org

Who is the 3GPP
3GPP ecosystem

- Participation in 3GPP is made possible by companies and organizations becoming Individual Members (IM) of one of the OPs.
- Specific inputs, in the form of market requirements may also come into the Project via any of the twenty Market Representation Partners (MRP) in 3GPP. These organizations have all signed up to the 3GPP Project scope and objectives.
- Lots of external cooperation with other standards bodies and a broad variety of other groups, by way of formal Liaisons.

Organizational Partners

More than 700 companies as individual members !

5G use cases
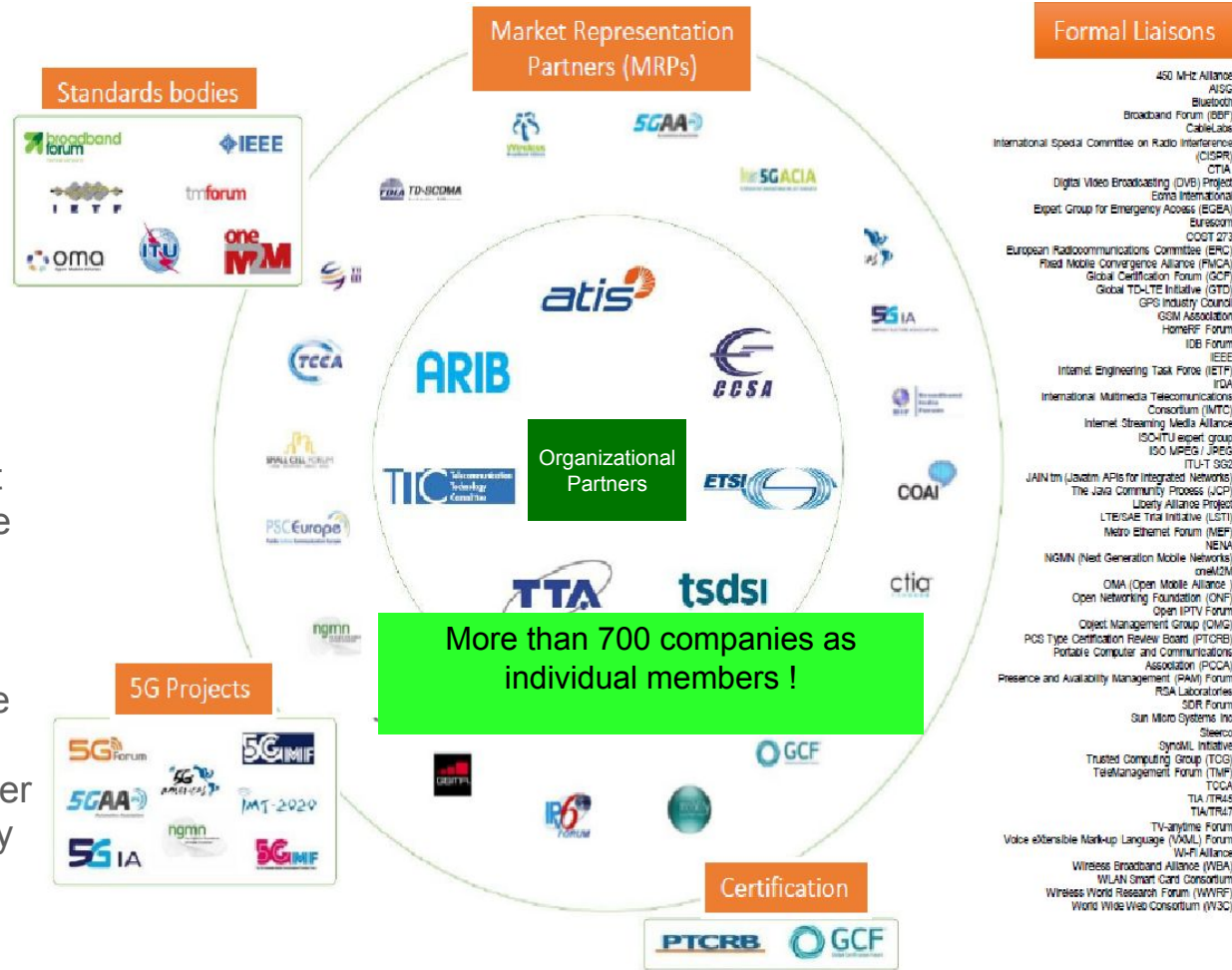
5G Usage scenarios

Enhanced Mobile Broadband

- Gigabytes in a second
- 3D video, UHD screens
- Work and play in the cloud
- Smart Home/Building
- Augmented reality
- Voice
- Industry automation
- Mission critical application, e.g. e-health
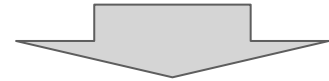- Smart City
- Self Driving Car

Future IMT

Massive Machine Type Communications

Ultra-reliable and Low Latency Communications

Massive IoT Characteristics
- Low power consumption
- Cheap service and devices
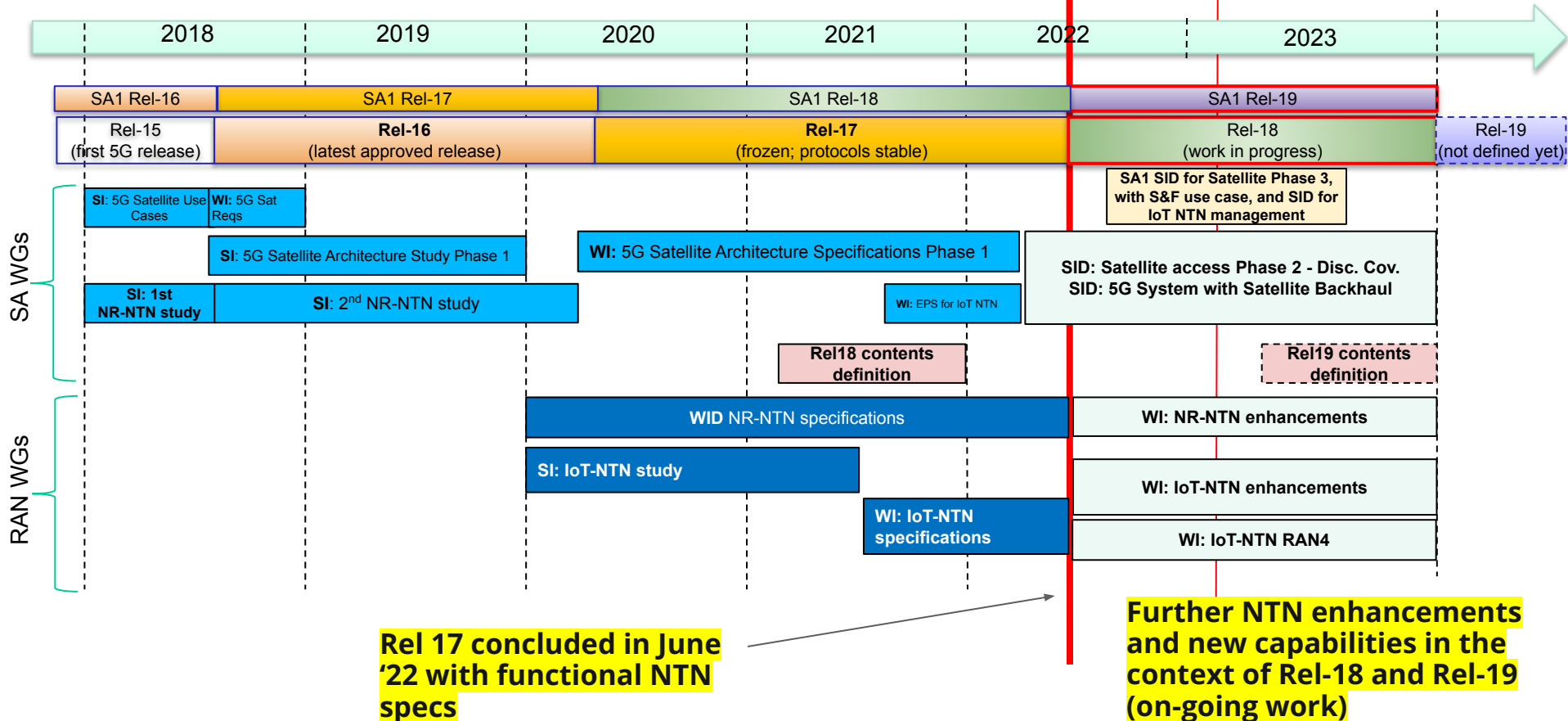- Low data transfer needs
- Mostly delay tolerant

NB-IoT

3GPP Roadmap on NB-IoT NTN

June 2022

Today

	2018	2019	2020	2021	2022	2023

SA1 Rel-16 | **SA1 Rel-17** | **SA1 Rel-18** | **SA1 Rel-19**

Rel-15 (first 5G release) | **Rel-16** (latest approved release) | **Rel-17** (frozen; protocols stable) | Rel-18 (work in progress) | Rel-19 (not defined yet)

SA WGs

- **SI**: 5G Satellite Use Cases
- **WI**: 5G Sat Reqs
- **SI**: 5G Satellite Architecture Study Phase 1
- **WI**: 5G Satellite Architecture Specifications Phase 1
- **SI**: 1st NR-NTN study
- **SI**: 2nd NR-NTN study
- **WI**: EPS for IoT NTN
- SA1 SID for Satellite Phase 3, with S&F use case, and SID for IoT NTN management
- SID: Satellite access Phase 2 - Disc. Cov. SID: 5G System with Satellite Backhaul
- **Rel18 contents definition**
- **Rel19 contents definition**

RAN WGs

- **WID** NR-NTN specifications
- **WI: NR-NTN enhancements**
- **SI: IoT-NTN study**
- **WI: IoT-NTN enhancements**
- **WI: IoT-NTN specifications**
- **WI: IoT-NTN RAN4**

Rel 17 concluded in June '22 with functional NTN specs

Further NTN enhancements and new capabilities in the context of Rel-18 and Rel-19 (on-going work)

SI: Study Item / Feasibility Analysis
WI: Work Item / Normative work
The roadmap is a simplified/illustrative representation of the 3GPP work plan for NTN

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Spectrum into 3GPP

Frequencies:

- Service link Target bands (3GPP Standard Rel-17)

NTN Satellite Band #	Uplink (UL) operating band	Downlink (DL) operating band	Duplex mode
255 (L band)	1626.5 MHz − 1660.5 MHz	1525 MHz − 1559 MHz	FDD
256 (S band)	1980 MHz − 2010 MHz	2170 MHz − 2200 MHz	FDD

Standardization Advantages are already coming

> satellite connections across all devices using Quectel's 5G-ready BG95x / BG77x series of LPWA modules. Quectel's modules will be the first to support satellite NTN, bringing seamless connectivity to devices, sensors, machines and more for an improved customer experience.
>
> Quectel NTN-ready modules (running the latest Rel-17 NTN firmware) will not require customers to make any changes to the way they design their hardware. Any device, sensor, or machine can be upgraded to support satellite connectivity. This means that consumer and enterprise customers worldwide will be able to connect via cellular or satellite without having to manually toggle between the two or require a separate device.

Source: https://www.quectel.com/news-and-pr/non-terrestrial-network-ntn-module

- Evolution of technology with the standard
- Avoid technology lock-in
- Interoperability between different operators
- Investment protection
- Value per money

Standardization Advantages are already coming
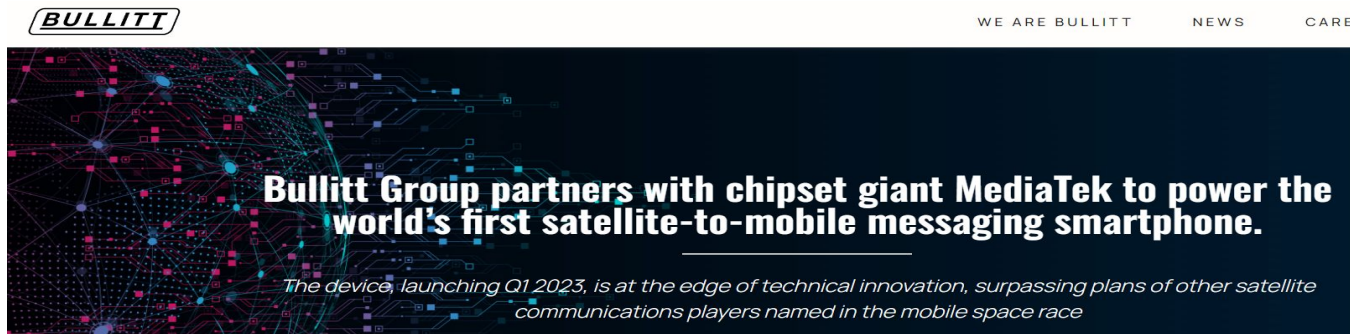
Source: https://bullitt-group.com/bullitt-group-partners-with-chipset-giant-mediatek-to-power-the-worlds-first-satellite-messaging-smartphone/

Bullitt and MediaTek have worked together over the last 18 months to enable the addition of direct to satellite communication in the next generation of Bullitt designed 5G smartphones. Bullitt is the first to use MediaTek's 3GPP NTN (Non-Terrestrial Network) chipset. Proprietary software and service components have also been developed in parallel to provide the OTT satellite messaging service.

We have known for a long time that the answer was in satellite but an 'invisible' and seamless integration into a smartphone creates enormous technical challenges. MediaTek and Bullitt share a pioneering spirit and a history of innovation so now, nearly two years into our relationship, we jointly stand at the forefront of a new era in telecommunications and the quickest, simplest way for our carrier channel partners to offer total peace of mind to their customers

Richard Wharton | Co-founder at Bullitt Group

03

Sateliot Solution & Architecture in EO use case

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Sateliot Architecture for EO use case

- Regenerative payload
- For LEO constellation
- Compliance to 3GPP NB-IoT NTN protocols and 3GPP/GSMA roaming architectures
- Fully compatible with real-time continuous coverage and always-on connection*
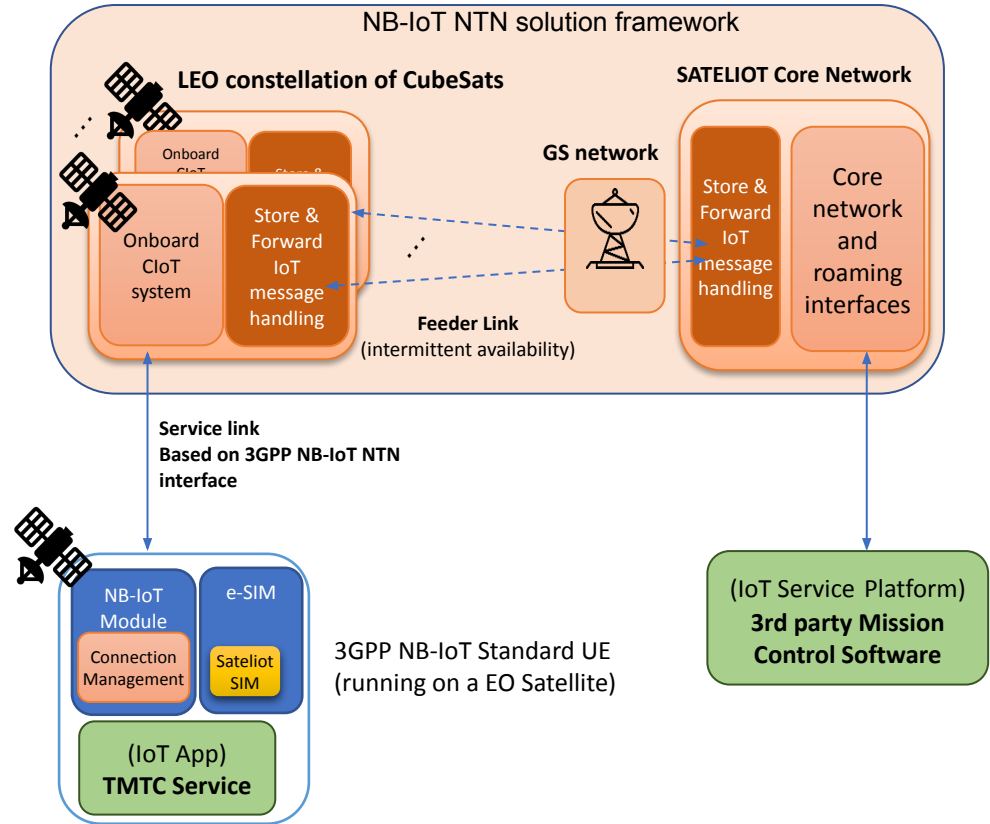
*At the beginning, suitable for delay-tolerant applications due to low density constellation.

Ground stations segment as a service available all around the globe and any 3rd party GS network

KSAT
KONGSBERG SATELLITE SERVICES

LEAFSPACE

What Sateliot can offer:

- Reference UE Device for In-Orbit test
- eNB & **UE firmware**
- E2E 3GPP NB-IoT NTN Standard Testbed with Flexible Payload EM
- Split Core Network architecture with Store & Forward mechanism

Compatible with:

✓ Dynamic satellite tasking
✓ Near-real time distribution of information to and from both ground and space nodes in the network
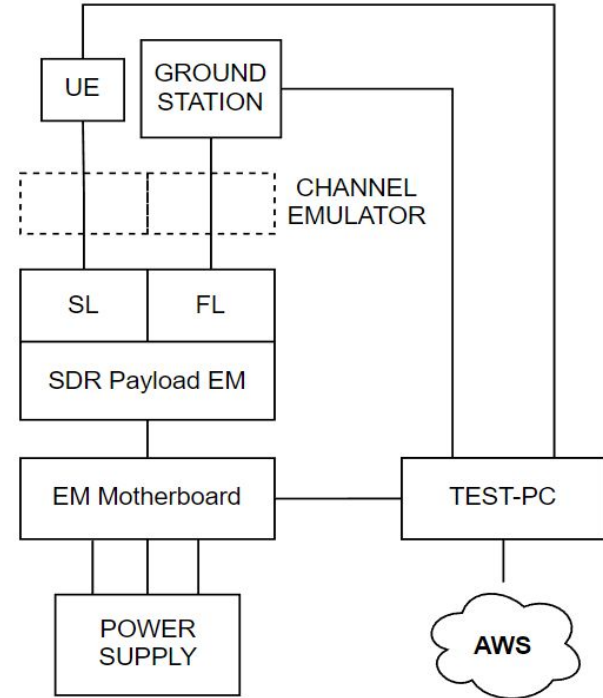
What Sateliot can offer:

SATELIOT_0: Ready For Flight E2E space demonstration including NB-IoT NTN adaptation, S&F functions, roaming to a real MNO and connecting a delay-tolerant IoT application for smart agriculture or similar.
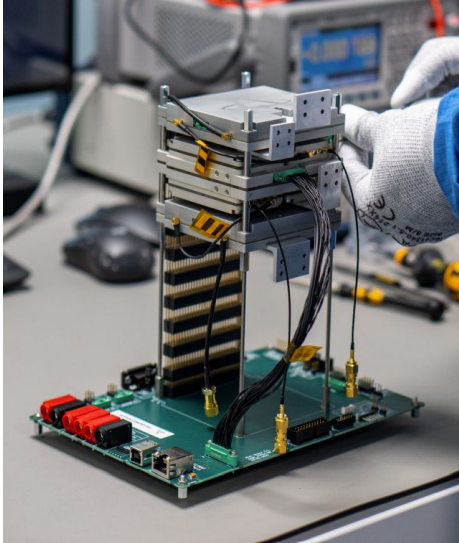
Testbed - Flexible Payload EM
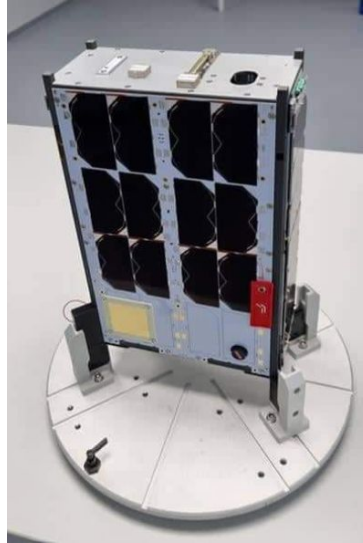
SATELIOT_0: E2E NB-IoT NTN In-Orbit-Demonstration-3

(Flight Heritage) 3B5GSAT: Satellite IoT Proof-of-Concept

An affordable UE for space mission ?

Z7000 - FPGA module:
- Xilinx Synq 7030 Programmable SoC
- Dual ARM Cortex A9 MPCore up to 800 MHz
- 1 GB DDR3 RAM and 32 GB storage
- Powerful FPGA module – 125K logic cells
- Linux operating system

Radio daughterboard for use in SDR platforms
- AD9361 Transceiver
- Band: 70 MHz to 6 GHz
- Channel bandwidth is tunable from 200 KHz to 56 MHz

Main Features:

- High-performance System-On-Chip (SoC) - Xilinx Zynq-7000 series
- Wide frequency range RF transceiver (AD9364)
- Full duplex communication **(Sateliot: Half Duplex for NB-IoT is enough)**
- SDR transceiver across several frequency bands: UHF, VHF, S-band and L-band

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Link Budget / paper IAC

International Astronautical Congress (IAC), Paris, France, 18-22 September 2022.

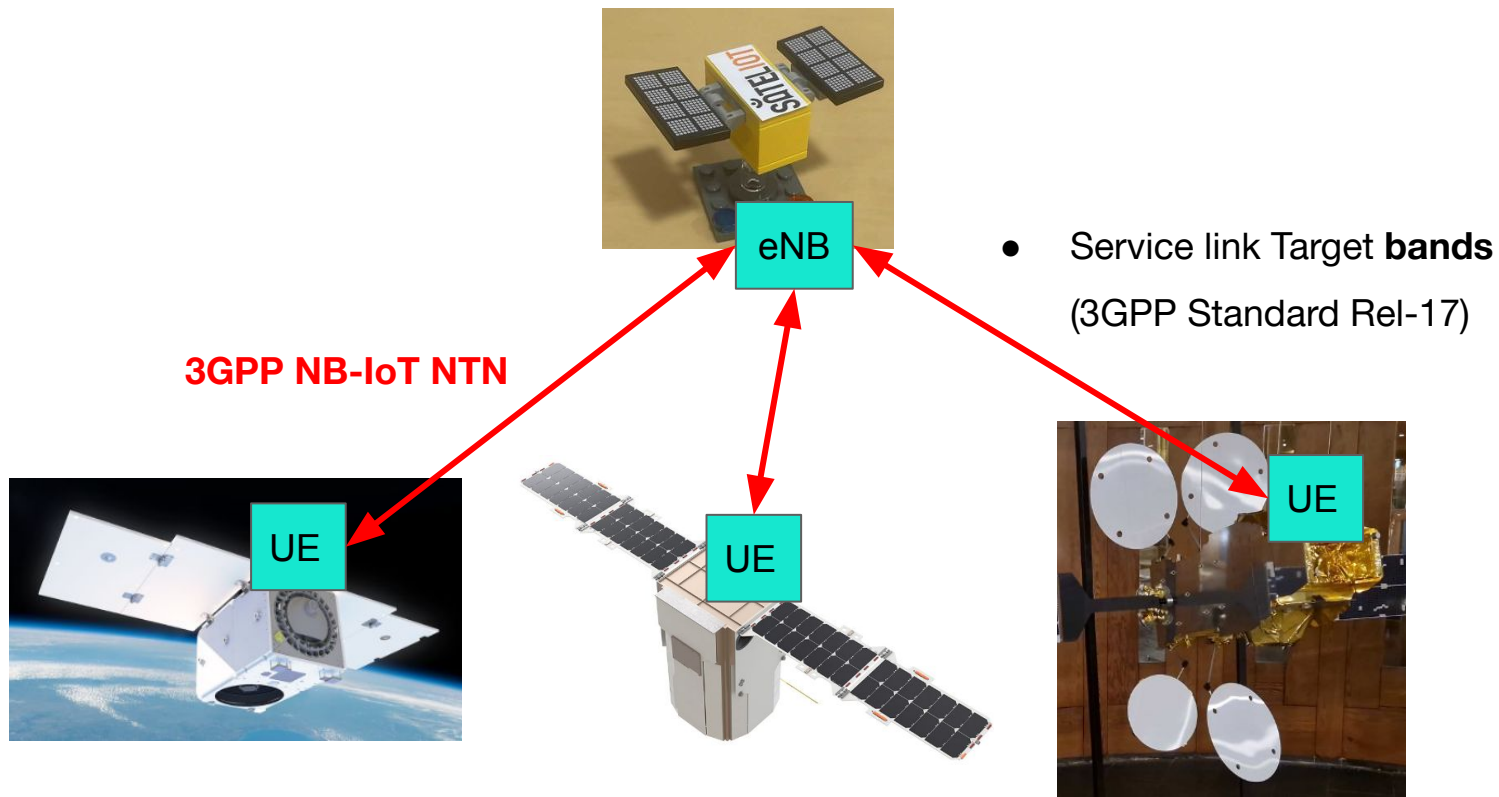**System level performance analysis for 3GPP NB-IoT NTN solutions with small satellites and sparse LEO constellations**

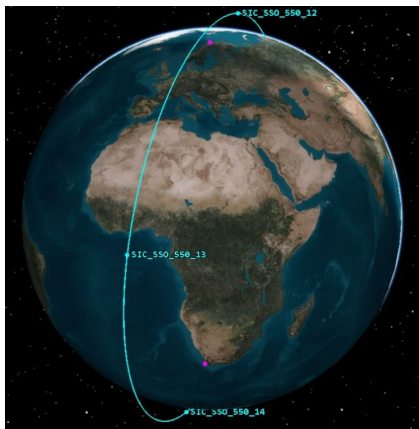| Parameter	Value
Orbital Height	550 km
Total transmission power	{33, 36, 39} dBm
Power for RF front-end	24 Watts
Peak antenna gain	9.3 dB
Half power bandwidth	50 degrees ; 30 degrees (cross track ; along track)
Noise Figure	4 dB
G/T	-19.5 dB

Table 3: Satellite parameters

Parameter	Value	
Transmission power	23 dBm	
Peak antenna gain	~~9.3 dB~~	**Typo 0 dBi UE**
Noise Figure	7 dB	
G/T	-31.7 dB	
Transmission mode	3.75 kHz	

Table 4: UE Parameters

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IoT4EO Use Case Vision

3GPP NB-IoT NTN

eNB

UE

UE

UE

- Service link Target **bands**

  (3GPP Standard Rel-17)

SIC-4 Orbital Plane 2023
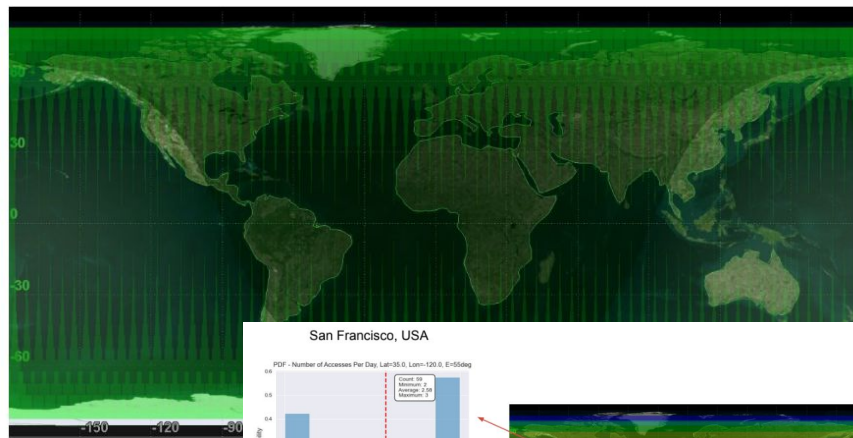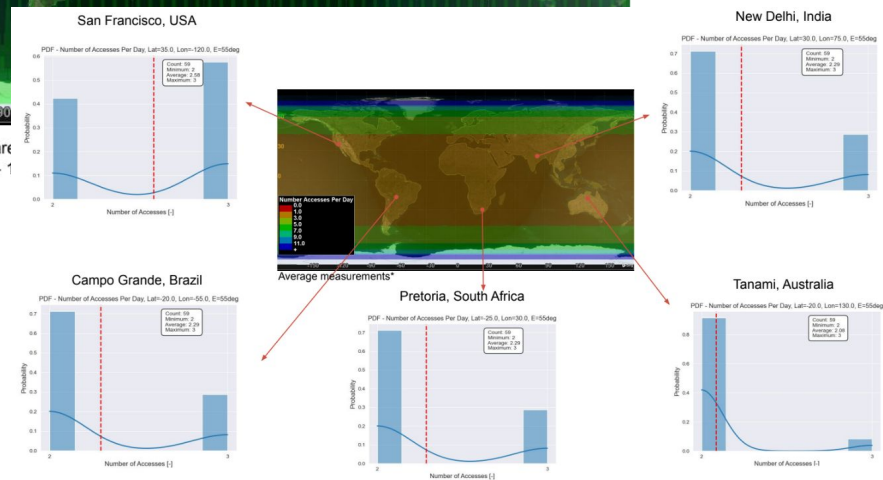
64 satellites: KPI for terrestrial service mean latency of less than 1h
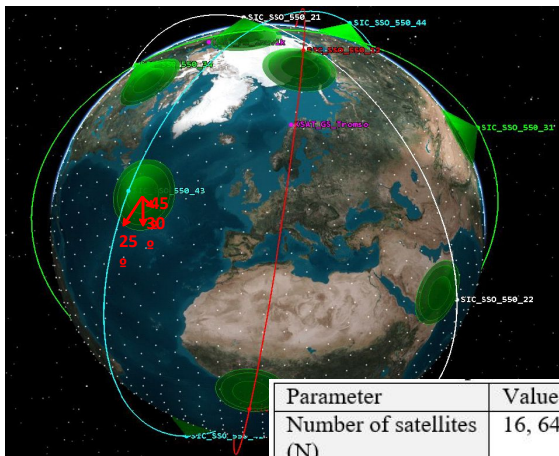
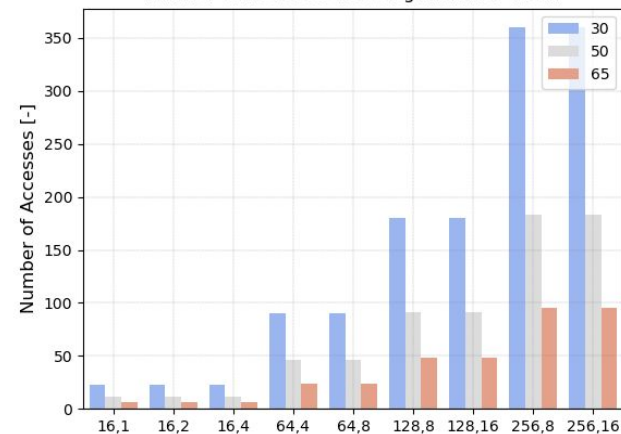| Parameter	Value
Number of satellites (N)	16, 64, 128, 256
Number of Orbital Planes (M)	1, 2, 4, 8, 16
Orbit Type	Sun Synchronous (SSO)
Altitude [km]	550
Walker constellation type	Star
Inter Plane Spacing	M-1
GS network	Cape Town, Punta Arenas, Sydney, Inuvik and Tromsø
GS minimum elevation angle	10º

Impact in MO Latency →

Number of Accesses at 30deg Latitude - Mean

MO Message Transfer Latency at 30deg Latitude - Mean
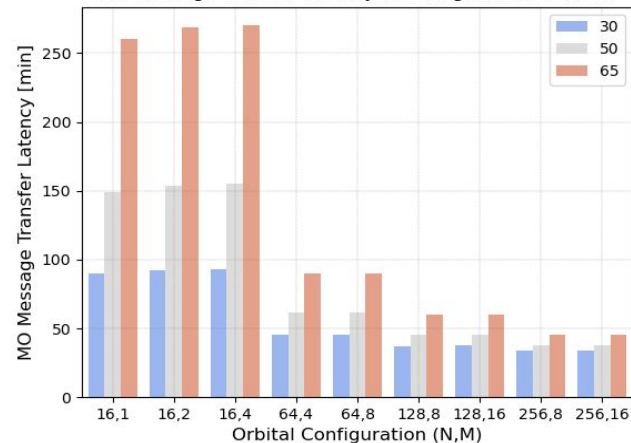
Thanks

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