

A photograph of a SpaceX Falcon Heavy rocket launch. The rocket is ascending vertically, leaving a massive, billowing plume of white and orange smoke and fire. The launch is taking place at dusk or dawn, with a bright sun low on the horizon to the right, casting a golden glow over the scene. Several tall, dark metal service towers are visible around the launch pad, their silhouettes against the sky. The overall atmosphere is dramatic and powerful.

5G Non-terrestrial networks (NTN) research at VTT

Marko Höyhtyä, Research Professor
Space Business Forum, November 2023

VTT in Space: 100+ experts

VTT's research in space technology aims at developing

- **State-of-the-art imaging sensors and services for satellite imagery analytics.**
- **Communication HW and solutions for integrating communication technologies in space and terrestrial networks.**
 - Strategic partnership with ESA on 5G/6G development since 2019
 - RF and millimetre wave collaboration with NASA/Jet Propulsion Lab



Satellite communications

- **Satellite communications enable connections everywhere in the air, ground, and sea (and deep space)**
- **Standardized systems enable interoperability.**
- **In many cases connection to satellites currently only possible with the equipment of the same vendor**
 - **E.g. Starlink is proprietary system**



Objective of 3GPP non-terrestrial networking (NTN) work

- 3GPP is the main standardization body for mobile networks such as 5G
- NTN work will include satellites as part of the 3GPP specifications
 - Promise of worldwide access to 5G services and growth of satellite industry
 - Standardized services and interfaces
- The work is conducted in three main technical specification groups (TSGs), further divided into working groups (WGs)



Defining user equipment and core network functionality

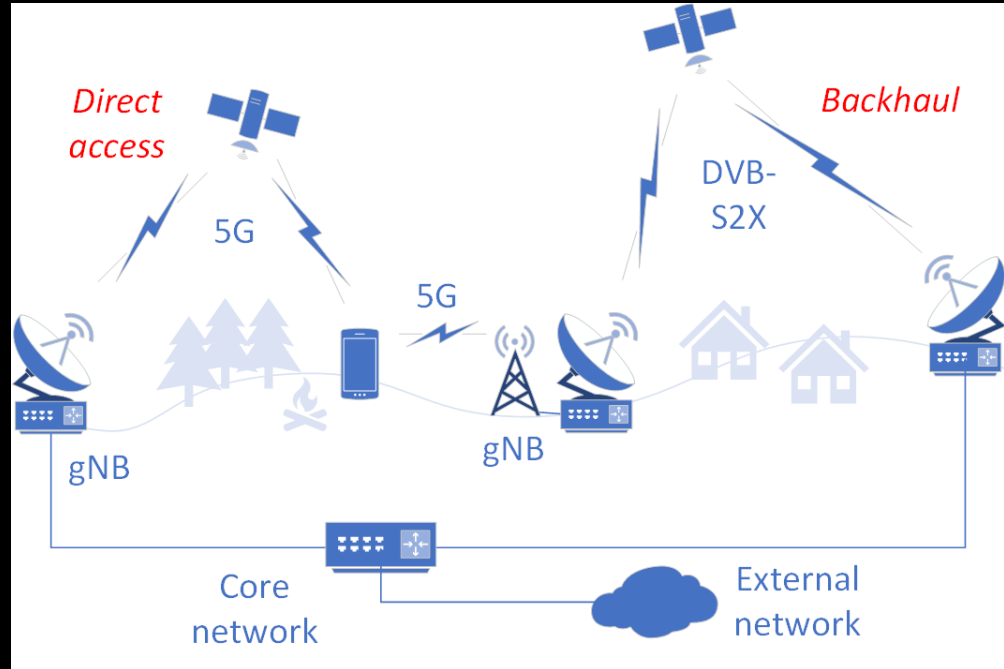
Radio layer functionalities, Network interfaces

System architecture, services Security



How 5G systems integrate satellites in practice: Two main ways

- 1) Handheld device can directly connect via satellite
- 2) Connection to the local base station that connects to core/outside world via satellite

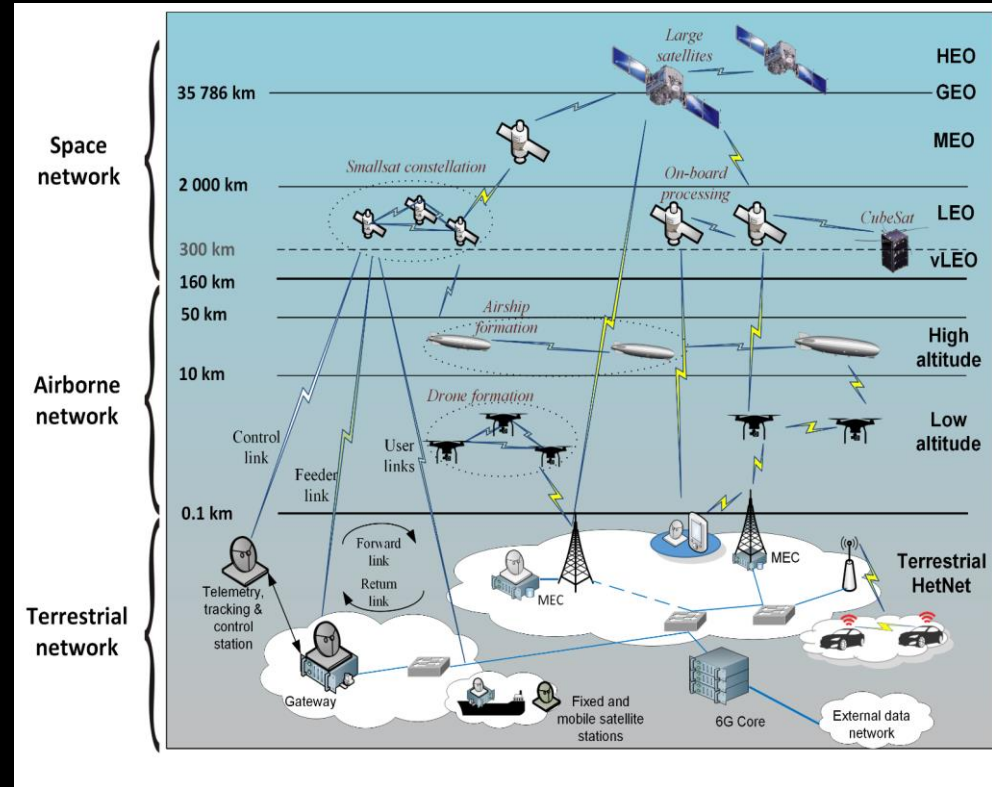


VTT competences in NTN: 5G and towards 6G SatCom

Multi-layer satellite systems: Towards 6G

Multi-layer systems will enable unprecedented possibilities

- In 5G integration of networks is “loose” → tighter in 6G
- VTT has done visionary work for next-generation networks architecture
- *Europe planning own IRIS² secure connectivity system as multi-layer activity ~ €6B – VTT contributing for testbed development*



Selected recent or on-going NTN projects



NTN security
OneWeb measurements



Three-dimensional architecture
Roadmap towards 6G



Machine-type connectivity
Remote areas and maritime
Public safety



NTN for mobile platforms,
Road safety
Starlink and Iridium
measurements



W-Cube: 75 GHz satellite and
Ground station



4SSTB

Simulation and emulation
testbed towards IRIS²



Multi-layer GEO-LEO networks for
Ultra-high availability and resilience

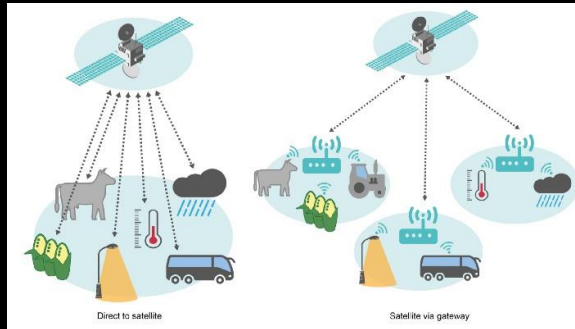


Direct 5G satellite connectivity for
commercial smart phones

Application areas



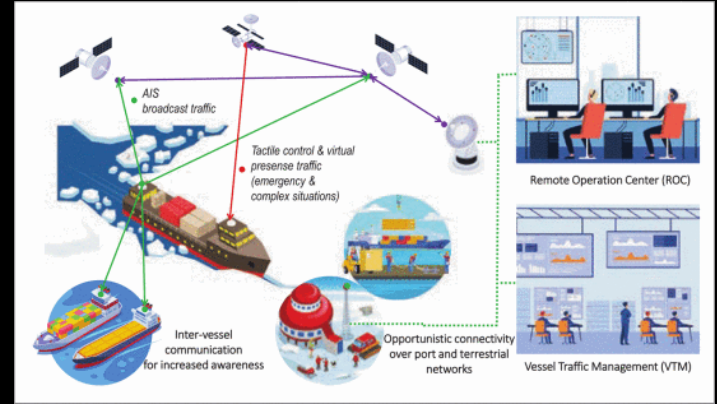
Public safety



Satellite IoT



SatCom for consumers:
Internet and handheld
connections

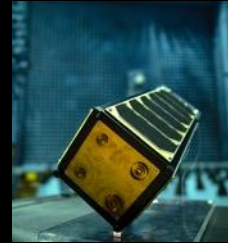


Autonomous/remote controlled systems;
Maritime and road traffic

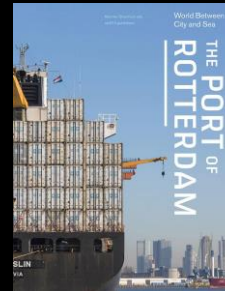


VTT Technical Competences in 5G NTN: Recent examples

- Ground segment HW & Payloads for satellites: Millimetre wave and software-defined technologies
- Satellite constellation design for LEO satellite systems
- Integration of 5G satellite and terrestrial networks
 - Direct satellite-to-handheld and backhauling techniques
 - Dynamic spectrum management



W-Cube satellite and ground station:
World's first 75 GHz signal from space



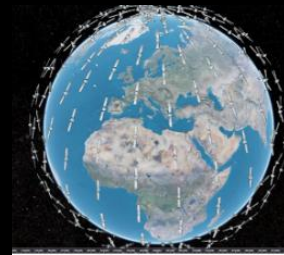
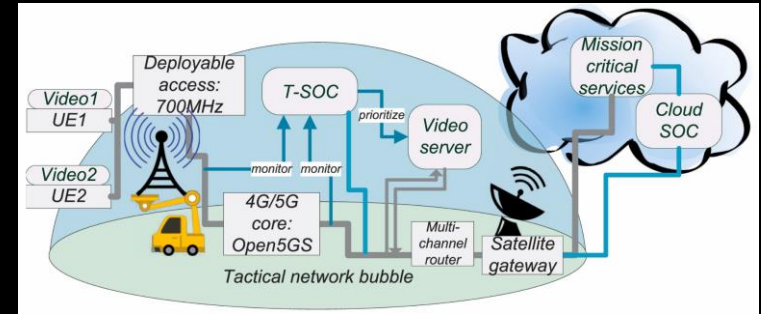
Dynamic spectrum pilot
under development in
Netherlands: 3.8-4.2 GHz



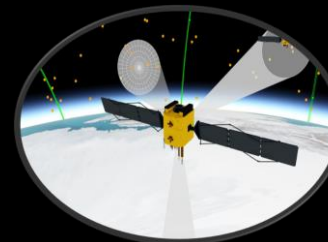
Advanced simulation systems,
e.g., SCNE tool developed with
ESA funding

NTN competences: Secure connectivity and space safety

- **Tactical security operations center (T-SOC):** Security monitoring of a local network (tactical bubble) and related adaptation of the traffic
- **Simulation testbed to support future space systems such as IRIS²**
- **5G satellites for debris detection:** Improving space safety with joint communication and sensing



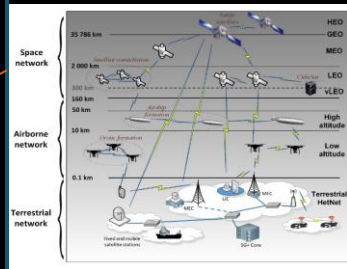
ESA 4SSTB, partly based on ESA SCNE
-VTT responsible for simulator



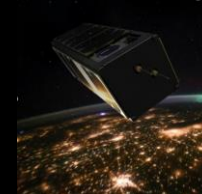
High Altitude Pseudo Satellite (HAPS) communications



Integrated satellite-terrestrial



Space and ground segment hardware



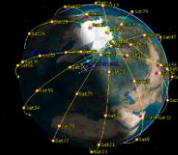
Development for selected verticals including autonomous systems, public safety, IoT



Positioning and arctic environment



Simulation and implementation



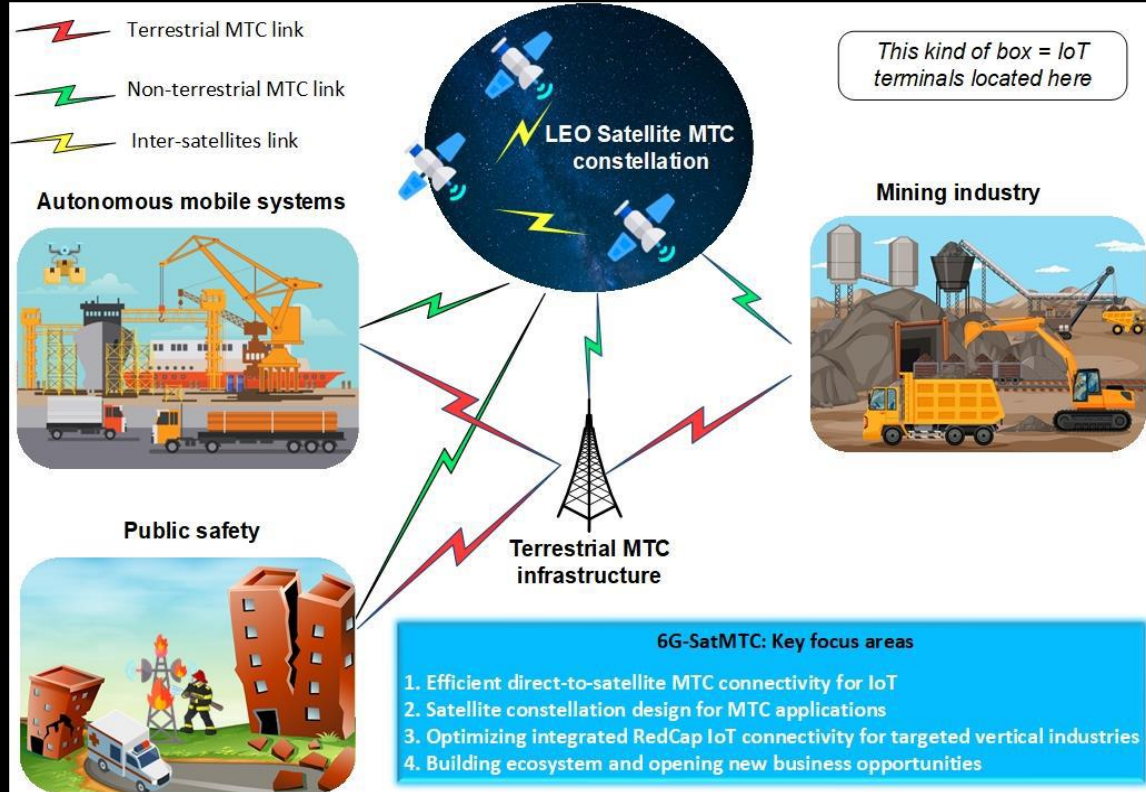
Cybersecurity



- Deep understanding on 3GPP NTN
- Advanced simulation tools
- Real satellite equipment in the 5G test network
 - LEO and GEO

6G-SatMTC project (4/2023-10/2025)

Developing integrated satellite-terrestrial systems and LEO satellite based MTC connectivity for demanding IoT applications.



Some references

Websites

- VTT Space technology:
<https://www.vttresearch.com/en/our-services/space-technology>
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Scientific articles

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- M. Vehkaperä et al., “Testbed for local area private network with satellite-terrestrial backhauling,” in *Proc. ICECCE*, Jun. 2021.
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- M. Höyhty et al., “Sustainable Satellite Communications in the 6G Era: A European View for Multi-Layer Systems and Space Safety,” *IEEE Access*, 2022.
- I. Ahmad et al., “Security of satellite-terrestrial communications: Challenges and Potential Solutions,” *IEEE Access*, vol. 10, pp. 96038–96052, Sep. 2022.

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