Satellite communications for critical users

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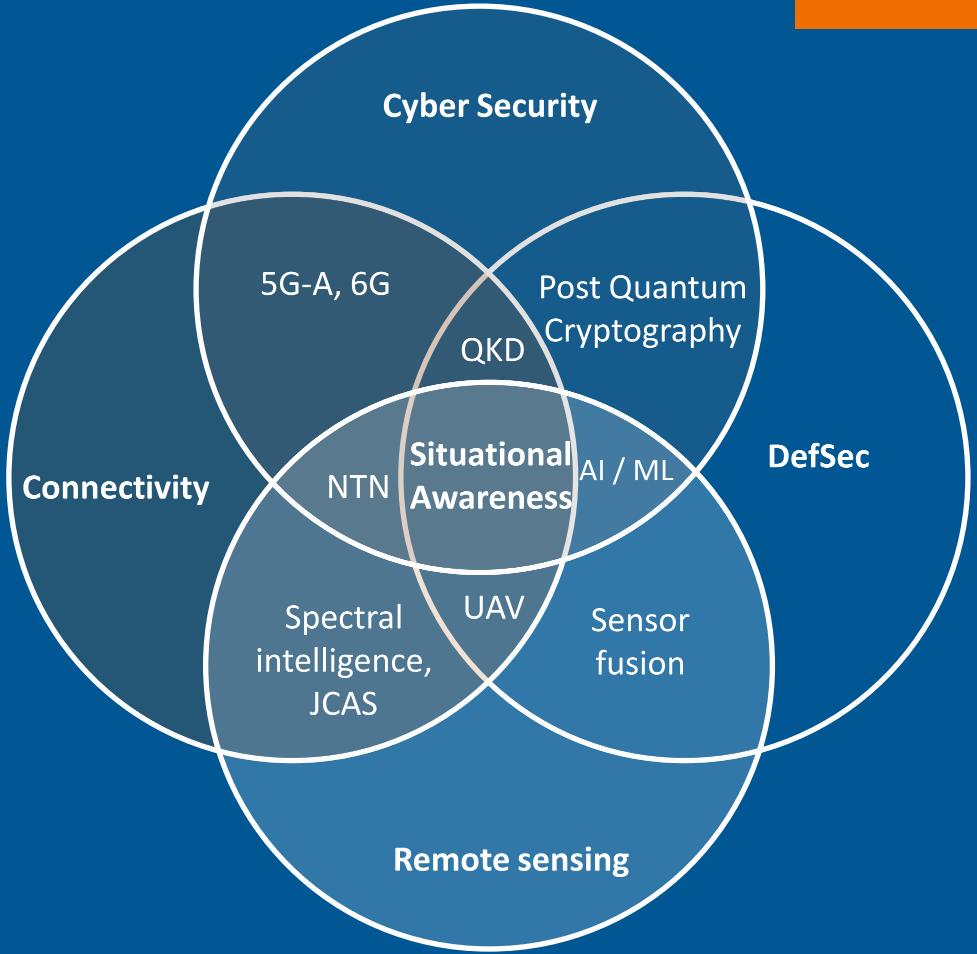
We focus on research and innovation relevant in defence, security, telecom, space and related vertical industries contributing to Europe’s technological sovereignty and resilience.

We collaborate with companies which are deploying connectivity, cybersecurity, digital trust, data analytics and situational awareness in their products and services.

We aim at secure connectivity infrastructure and situational awareness on the surrounding world

- **Cyber Security**
  - Applied Cryptography
  - Cybersecurity for mission critical networks
  - Cyber security testing & security exercises
  - AI-enhanced cybersecurity
  - Quantum-safe cryptography
- **Connectivity**
  - 5G-Advanced, 6G and NTN networks
  - 5G test and experimentation network for development of new network technologies and services.
  - 6G communication & sensing
- **Remote sensing**
  - AI based Earth Observation analysis
  - Sensor fusion
- **Defense and Security**
  - DIANA accelerator and test centres in Finland



VTT in Space: 100+ experts

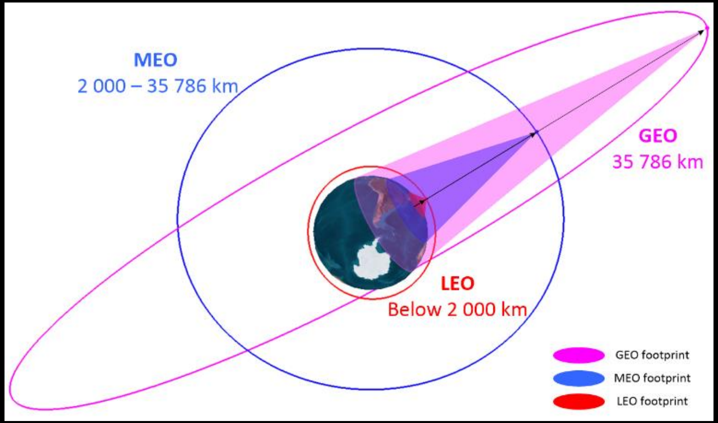
VTT's research in space technology aims at developing

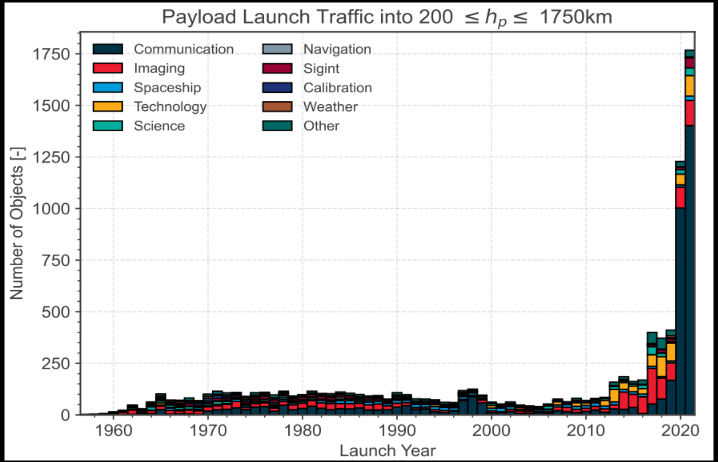
- **State-of-the-art imaging sensors and services for satellite imagery analytics**.
- **Communication HW and solutions for integrating communication technologies in space and terrestrial networks**.
    - Strategic partnership with ESA on 5G/6G development since 2019
    - RF and millimetre wave collaboration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

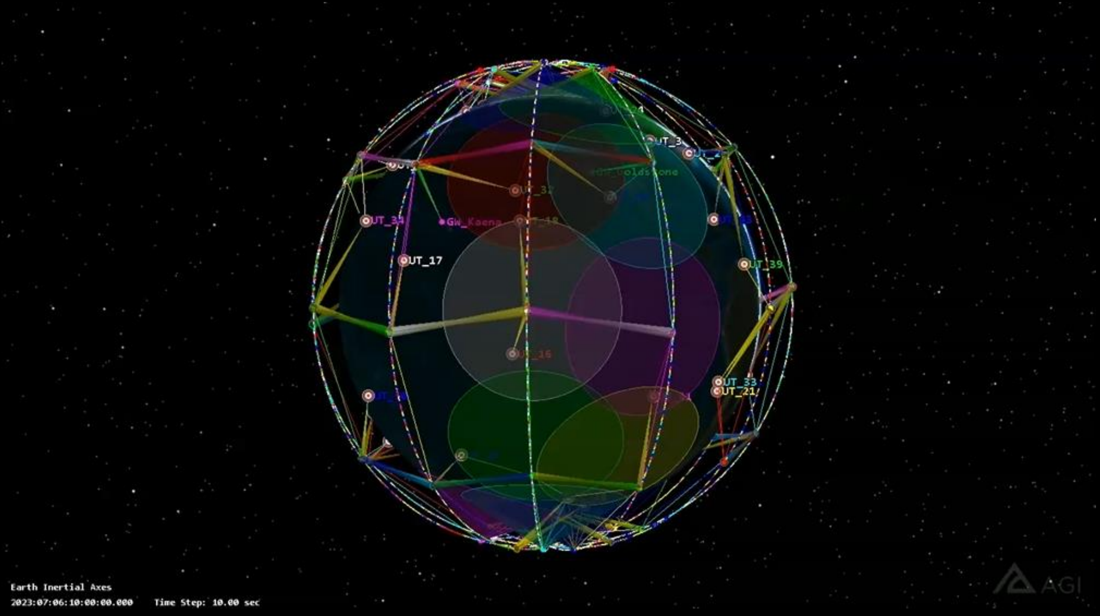
The combined use of satellite and terrestrial networks will provide more resilient connectivity and additional capacity for critical users.





Satellite constellation design and analysis

- **Number of satellites and their orbits**
- **Terminals**
- **Ground stations**
- **Desired coverage and services**



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

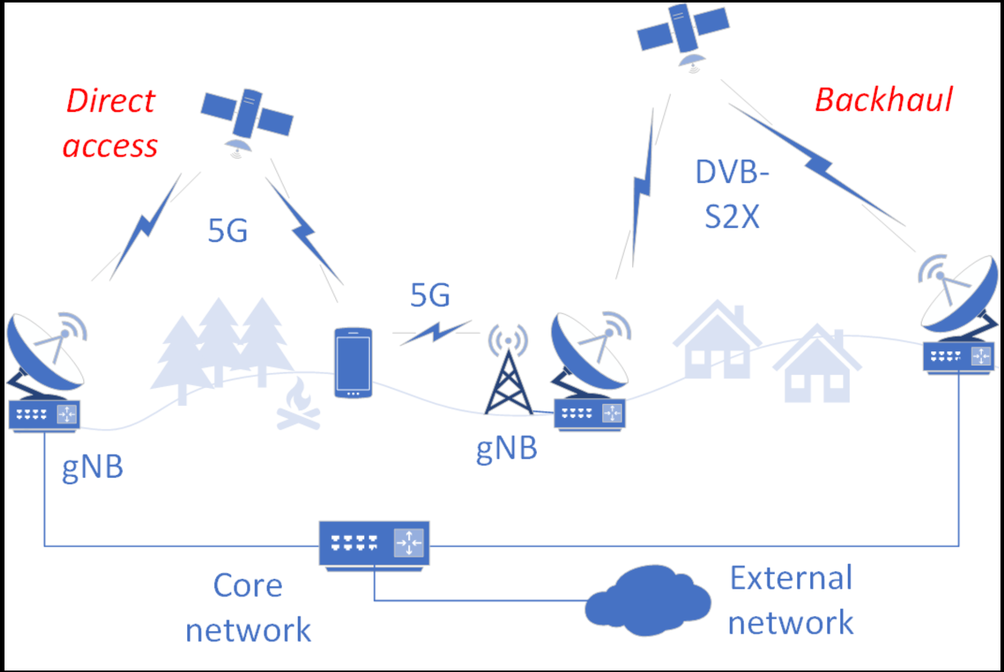
- **The work is conducted in three main technical specification groups (TSGs), further divided into working groups (WGs)**

TSG CT Core Network & Terminals	TSG RAN Radio Access Network	TSG SA Service & System Aspects
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



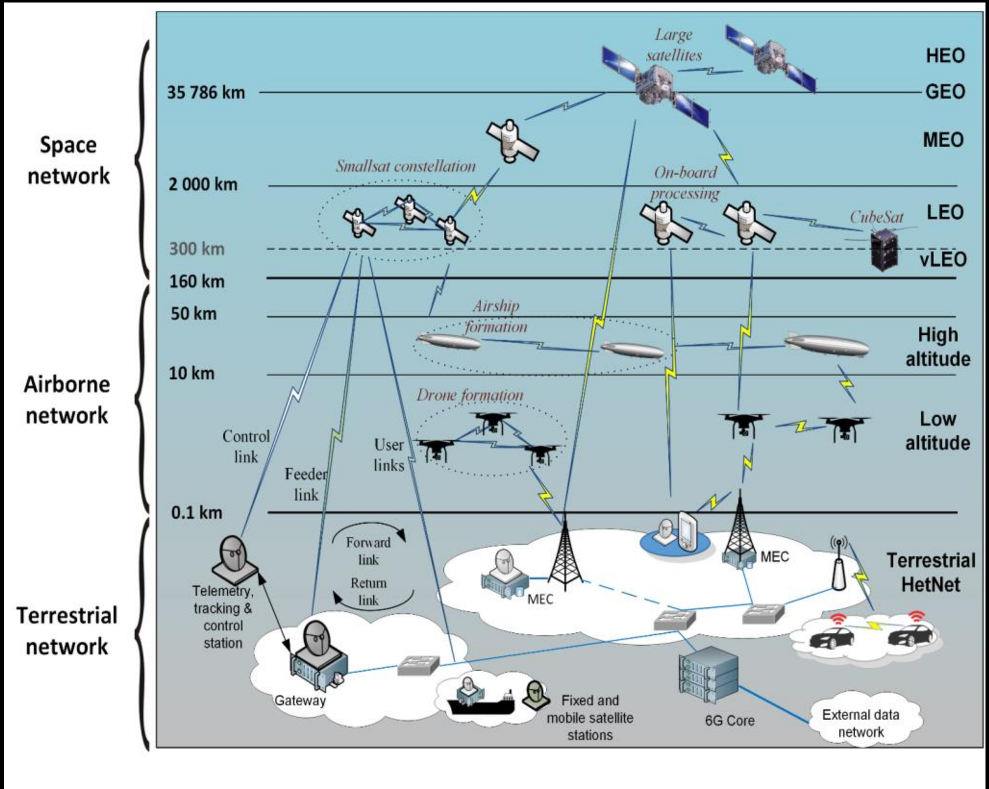
VTT competences in NTN: 5G and towards 6G SatCom

Multi-layer satellite systems: Towards 6G

VTT

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***



M. Höyhtyä et al., "Sustainable Satellite Communications in the 6G Era: A European View for Multi-Layer Systems and Space Safety," *IEEE Access*, Sep. 2022.

Selected recent or on-going NTN projects

VTT

AI-NET-ANTILLAS

NTN security
OneWeb measurements

6G_Sat

Three-dimensional architecture
Roadmap towards 6G

6G-SatMTC

Connectivity for machines
Remote areas and maritime
Public safety

5G ROUTES

5G-SAFE+

NTN for mobile platforms,
Road safety
Starlink and Iridium measurements

esa

W-Cube: World's first 75 GHz satellite and Ground station

4SSTB

Simulation and emulation testbed towards IRIS^2

MLSS

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

5G COSMO

Direct 5G satellite connectivity for commercial smart phones

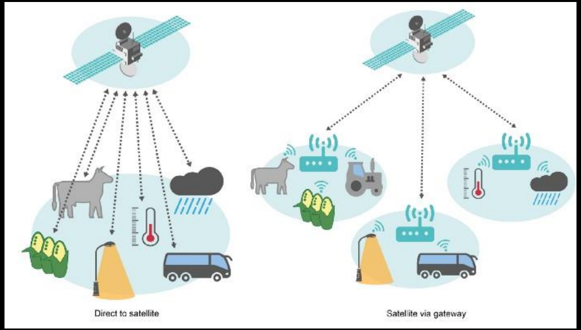
Application areas

Public safety

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

SatCom for consumers: Internet and handheld connections

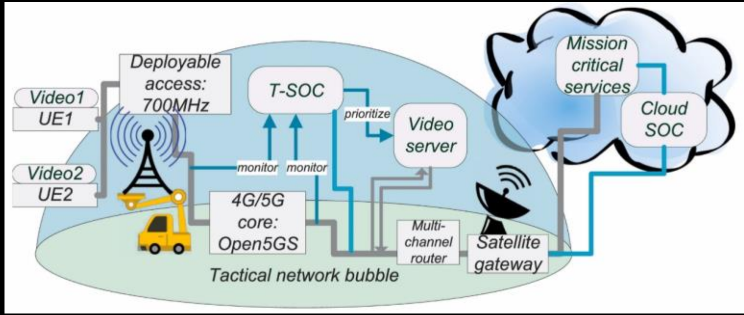
Autonomous/remote controlled systems; Maritime and road traffic

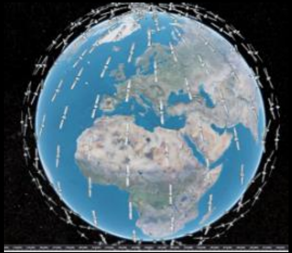


Satellite IoT

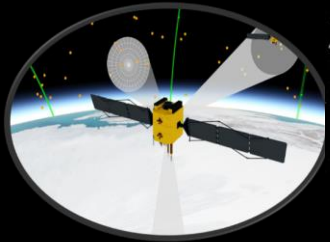
NTN competences: Secure connectivity and space safety

- **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





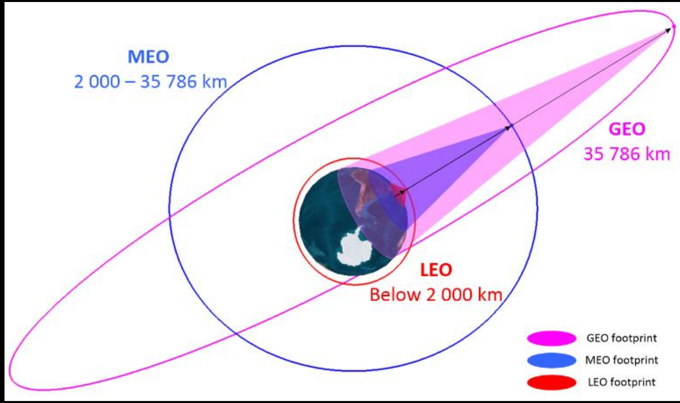
ESA 4SSTB, partly based on ESA SCNE
-VTT responsible for simulator



Results from measurements of GEO and LEO satellite systems

Summary of SatCom measurements

- Capabilities of current satellite systems in arctic regions were studied and their performance both Uplink (UL) and Downlink (DL) directions was measured.
- Several low orbit (LEO) ja geostationary orbit (GEO) satellites were used
- **Findings**: Delays, coverages, and data transfer speeds in some LEO systems are good in northers regions. Data is routed through several countries even if connection is from Finland to Finland.



Satellite systems at different orbits and their coverages on ground.

Measured systems:

iridium
OneWeb
Viasat
STARLINK

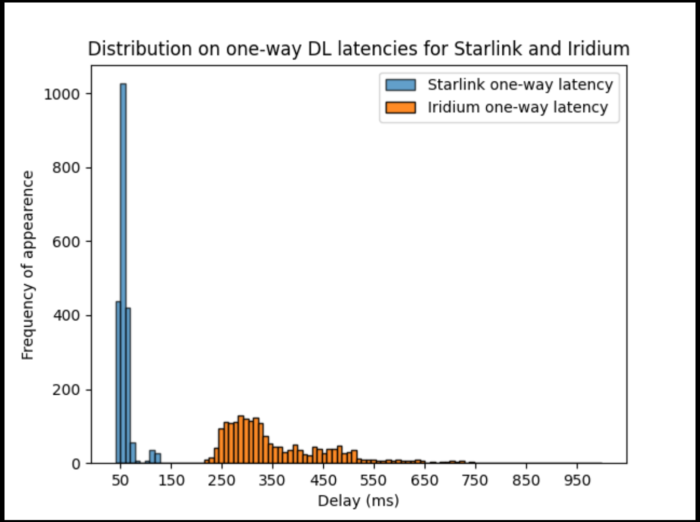
Measurements with Starlink and Iridium devices

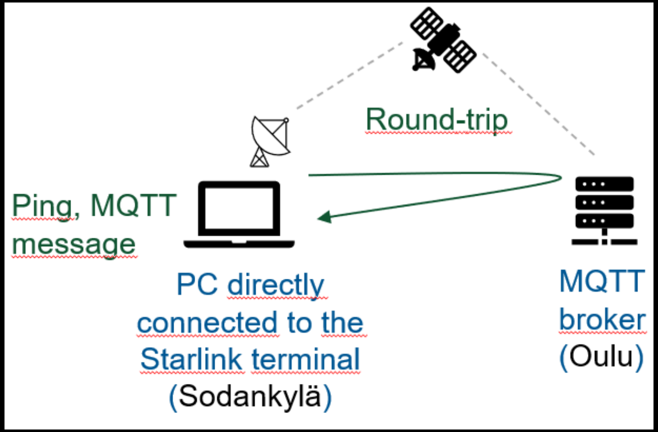
Iridium Certus terminal,
A few hundred kbps

Starlink terminal on top of a car (Used terminal is designed for static/nomadic use.)

Stralink terminal on the ground

Delay and throughput measurements in Oulu and Sodankylä





	Min	Max	Average
DL	102.7 Mbps	250 Mbps	176.1 Mpbs
UL	16 Mbps	64.4 Mbps	35.3 Mbps

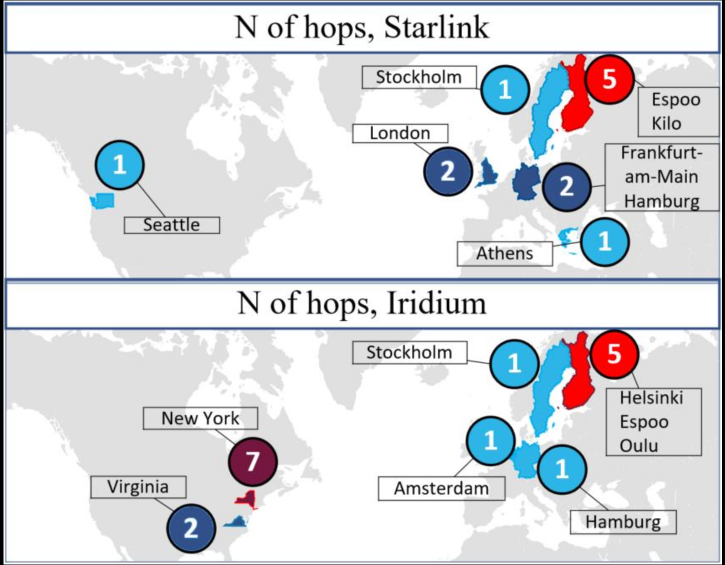
Data throughput

Latency	average
Ping	123.1 ms
MQTT	503.2 ms

Round-trip delays

Further information

Iridium and Starlink can route the data via U.S even when source and destination are in Finland.



OneWeb system in Kajaani:

- 100Mbps DL / 20 Mbps UL (max)
- Ping delay ~200 ms
- Ground station in London and PoP-server in Wermerveer → sea cables

Viasat GEO performance:

- 50Mbps DL / 10 Mbps UL
- Ping delay around 700ms
- Unreliable in Northern Finland

Conclusions

Satellite communications can be used to support critical systems and critical infrastructure. However, careful analysis of signaling and data to be transferred need to be done. Selection of the best system to support requirements must take into account criteria such as:

- Availability of the services
- Security level (incl. where the data is routed)
- What is the achievable throughput, latency and jitter (requires measurements at the location of interest)
- Cost of the terminals and the service

→ VTT is currently both developing next-generation technology as well as assessing current state-of-the art systems.

Some references

Websites

- VTT Space technology: https://www.vttresearch.com/en/ourservices/space-technology

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- A. Anttonen et al., "Space debris detection over intersatellite communication signals," *Acta Astronautica*, vol. 187, pp. 156–166, Oct. 2021.
- M. Höyhtyä et al., "Sustainable Satellite Communications in the 6G Era: A European View for Multi-Layer Systems and Space Safety," *IEEE Access*, 2022.
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beyond the obvious

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