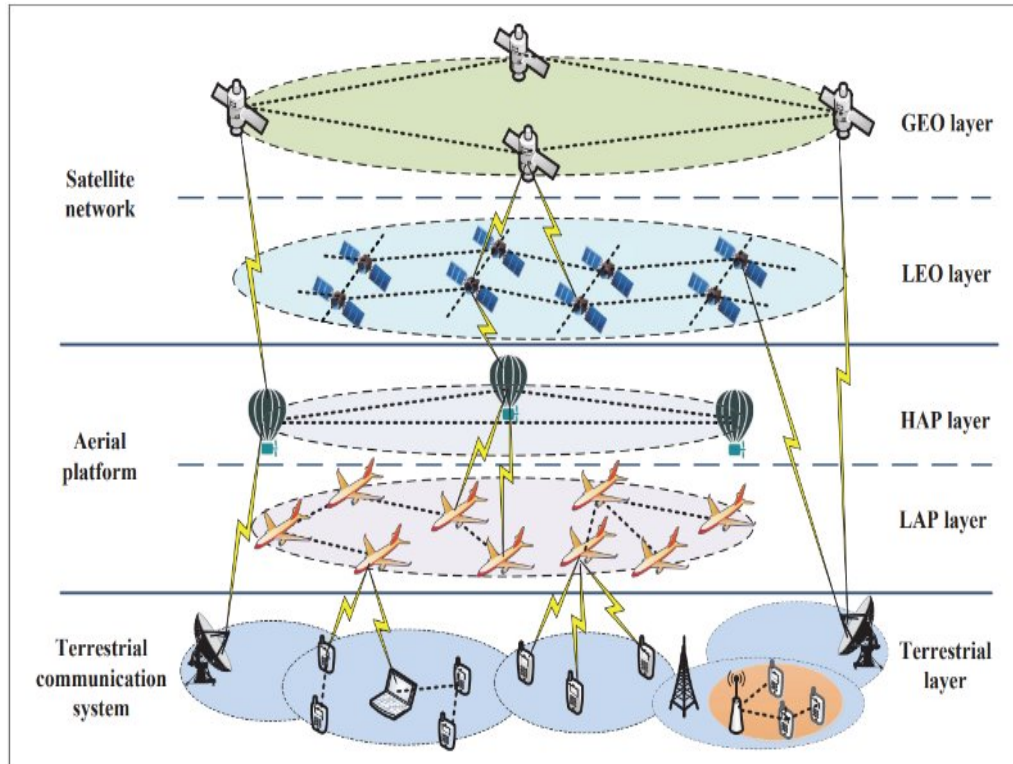


Datacom Industry Association Summit 2026



TN-NTN Integration towards 6G services

Francesco Matera
Fondazione Ugo Bordoni

“Spectrum Sharing” agreement with the Italian Ministry of Enterprises and Made in Italy (MIMIT), dated 1 August 2024 (CUP:B85G24000170001)

DIA Summit Pisa, October 13, 2026

Outline

- The **Datacom Industry Association** (DIA) drives innovation in datacom technologies and their enabled infrastructures:

In this talk NTN and NT integration;

- Services and use case for NTN
- NTN system and architectures
- Towards zero touch (6G), i.e. AI Native
- Where data analytics and AI elements
- Agent AI- Intent base Networks
- Security issues
- Conclusions

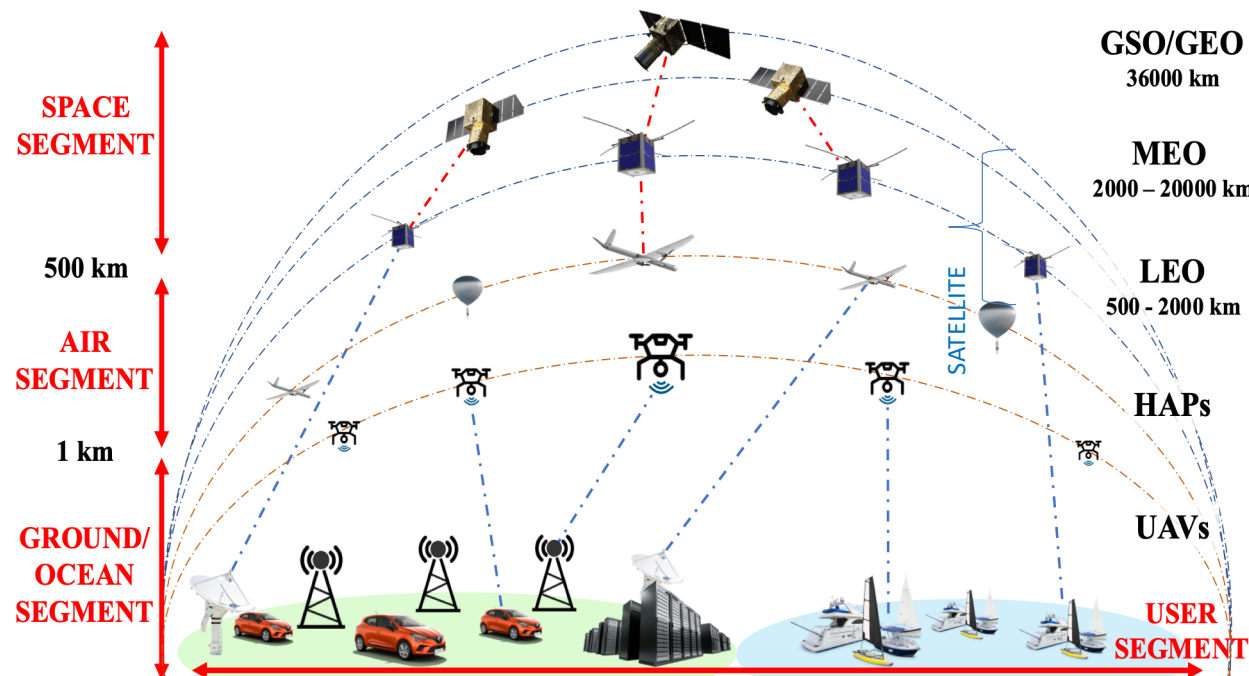
Integrated Terrestrial / Non-Terrestrial Networks: from 5G to 6G

enhanced Mobile
Broadband (eMBB)

5G Pillars

Ultra-Reliable Low Latency
Communications (URLLC)

Massive Machine Type
Communications (mMTC)



ITA NTN: Integration of Terrestrial and Non-Terrestrial
Networks



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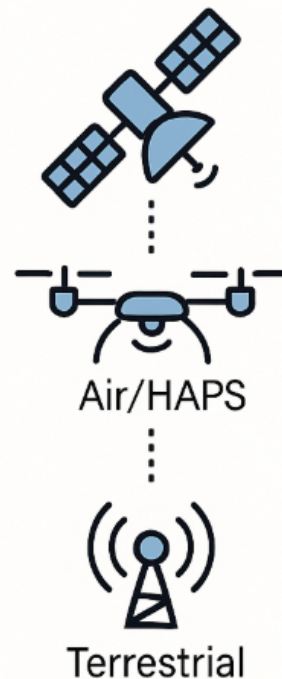
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Main Opportunities and Challenges in TN-NTN Integration

Opportunities

- Ubiquitous coverage
- Resilience & redundancy
- 3D network capabilities
- New use cases
- Dynamic resource sharing
- Support for 6G vision



Challenges

- Latency & Doppler effects
- Heterogeneous architectures
- Dynamic orchestration complexity
- Spectrum coordination
- Standardization gaps & evolution

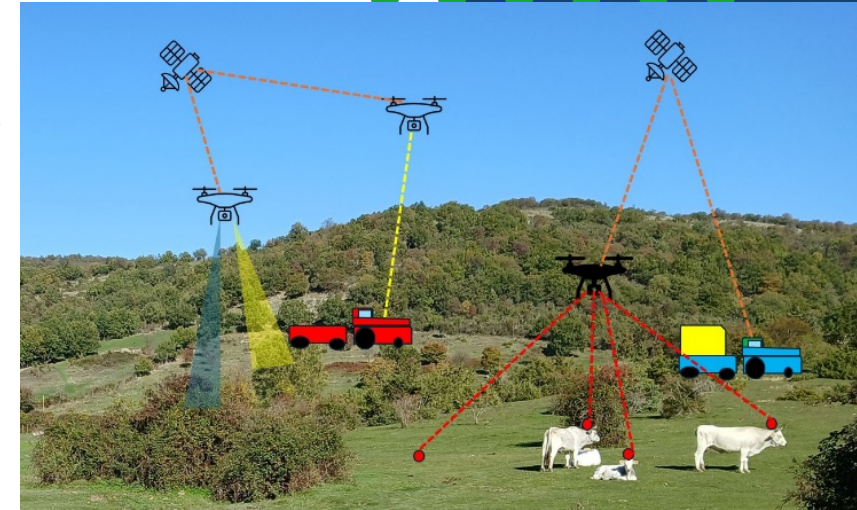
Use Case Characterization

Use Case Category	Specific service	Latency	Reliability	Availability	User Data Rate
Urban/Suburban area	Traffic offloading in event scenarios	≤500 ms	99.9%	N.A.	1–10 Mbps
Rural/Remote area	Coverage of non-connected areas	≤500 ms	99.9%	N.A.	1–10 Mbps
	Firefighters / Voice communication	≤100 ms	99.9%	N.A.	100–300 kbps
	Firefighters / Very critical video	≤10 ms	99.9%	N.A.	10–20 Mbps
	Interactive Aerial Telepresence	≤10 ms	99.9%	N.A.	1 Gbps (video) / 10 Mbps (commands)
Transport systems	Automotive / HD-maps	<100 ms	N.A.	99.9%	DL 16 Mbps / UL 4 Mbps
	Automotive / V2I continuous flow	100 ms	N.A.	95%	50 kbps
	Automotive / Platooning	Not sensitive	N.A.	95%	50 kbps
Drones for Delivery	Very critical video	≤10 ms	99.9%	N.A.	Very high (20 Mbps up to 1 Gbps)
IoRT	Very critical video	≤500 ms	95%	N.A.	1 kbps – 1 Mbps
Maritime sector	Maritime broadband	≤500 ms	99.9%	N.A.	≥2 Mbps
	Autonomous vessels	≤10 ms	99.9%	N.A.	≥100 kbps → Mbps
	Search & Rescue	≤100 ms	99.9%	N.A.	100–300 kbps
Telemedicine	X-ray screening	<1 s	100%	99.99%	1000 bits/s
	CT Analysis	<1 s	100%	99.99%	10 Mbps
	Red Cross	<1 s	100%	99.99%	3–4 Mbps
	Mobile Unit Red Cross	<1 s	100%	99.99%	10 Mbps
	Smart Voice App	<1 s	Not required	99.99%	2 Mbps

G.Piro «Rethinking Global Digital Connectivity with Non-Terrestrial Networks» Restart Planary January 19-21, Rome 2026

NTN for agriculture

- Optimized use of fertilizers and pesticides, improving plant health.
- Optimized irrigation, avoiding under- or over-irrigation and enhancing sustainability.
- Remote monitoring, diagnostics, and control of machinery to support automation in farming.



NTN for Automotive



Edge Computing (EC) in TN-NTN Integration

Key Points

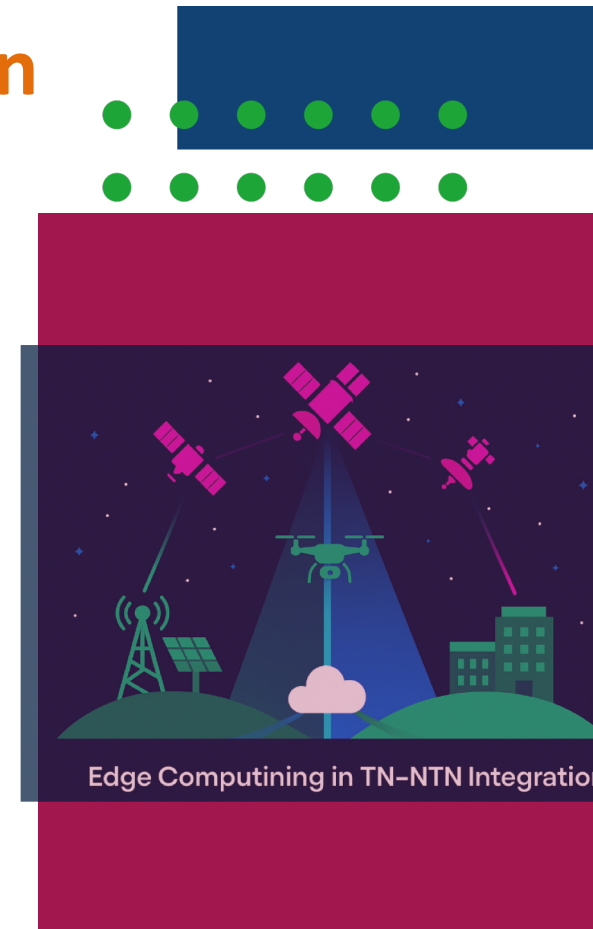
- 6G will enhance **EC** across TN & NTN
- EC resources (compute + storage) crucial in NTN (LEO, HAPS, UAVs)
- Multilayer **TN- NTN EC framework** → heterogeneous, low-latency services

Integration Benefits

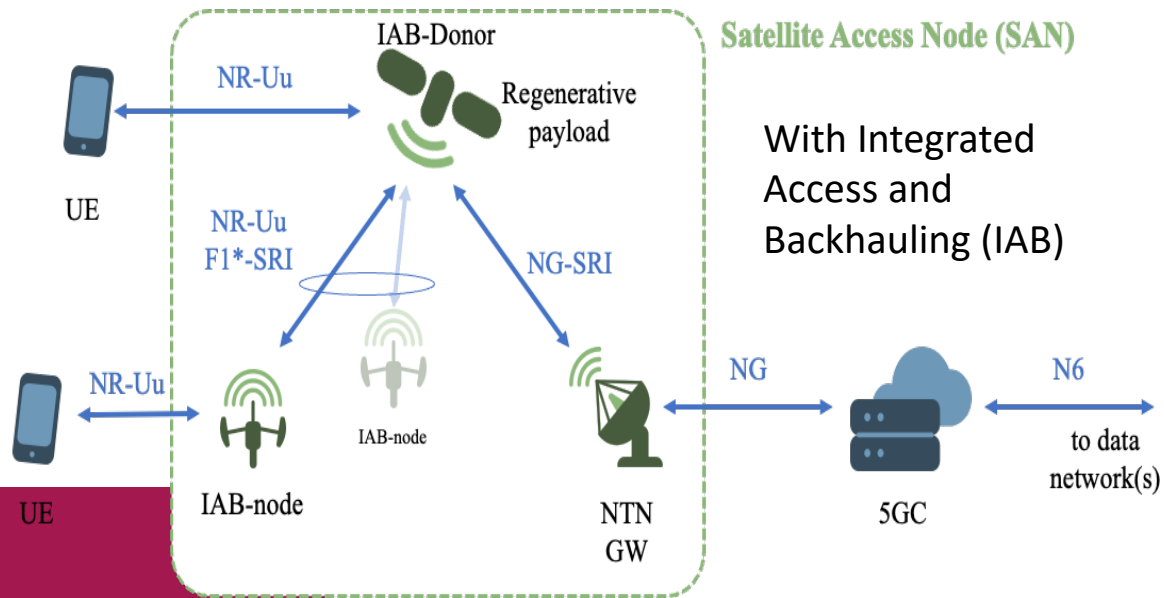
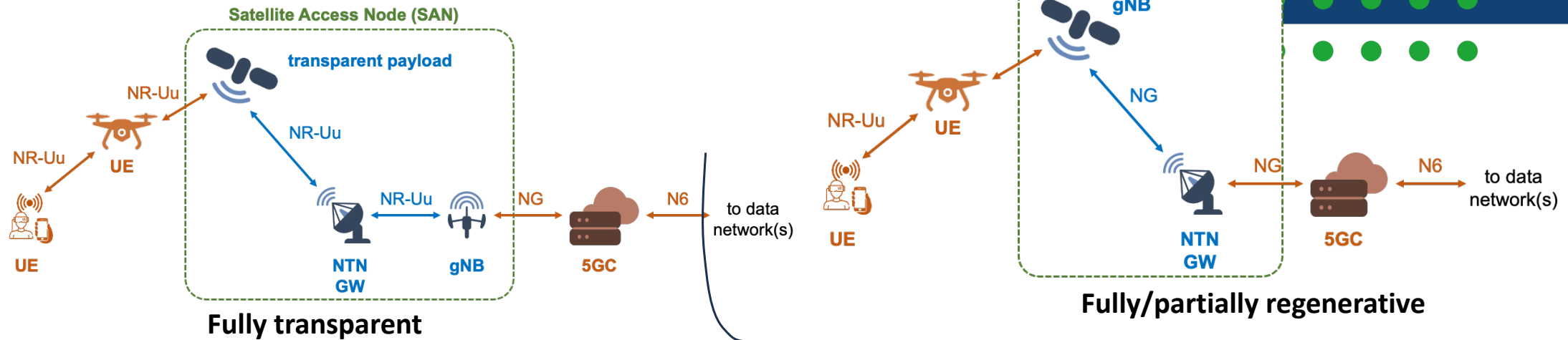
- LEO satellites with EC → high-quality services in remote areas
- NTN platforms boost coverage & capacity
- Relay & routing via inter-/intra-satellite links to TN clouds
- Virtualization (VMs, containers) for efficient EC resource use

Future

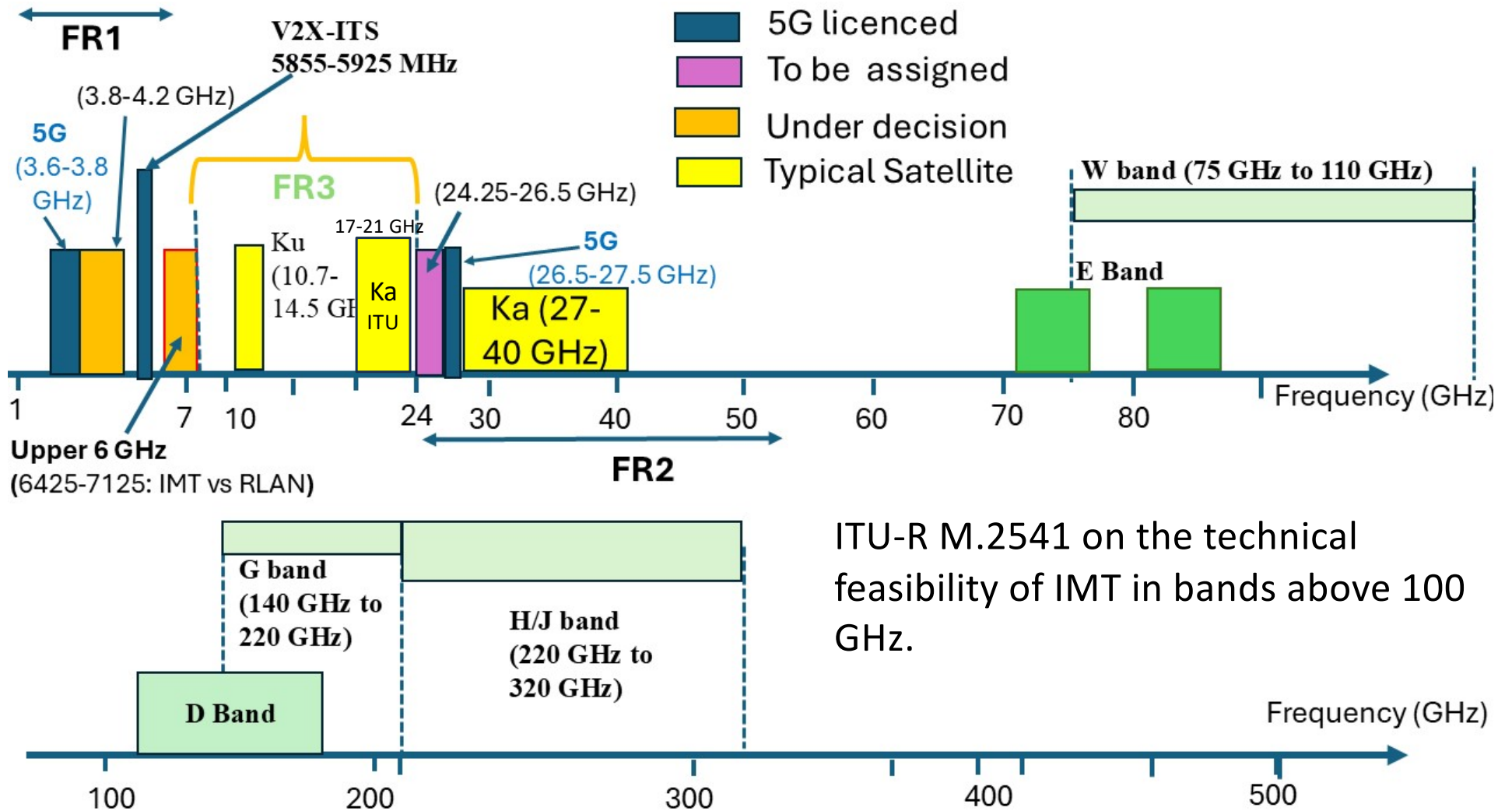
- Cloud and Data Center infrastructures in the space



Architectures



Exploiting spectrum



Coexistence issues

fixed-satellite-service
Earth-to space (FSS E-S)
interferer and fixed-
service (FS) Wireless Local
Loop Point-to Point (FS
WLL PP)

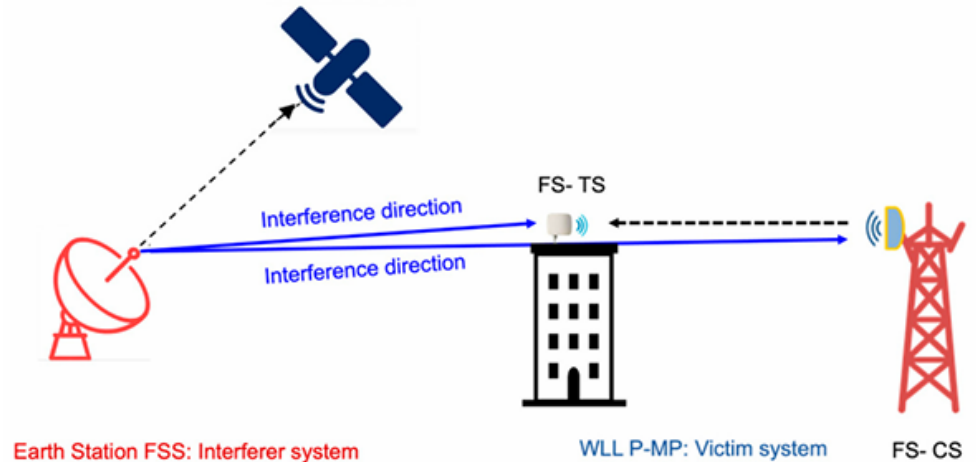


Figure 1. Coexistence scenario: FSS E-S interfering FS WLL P-MP.

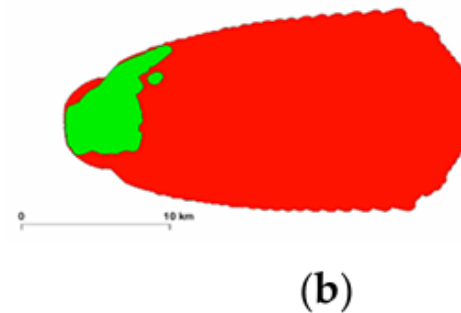
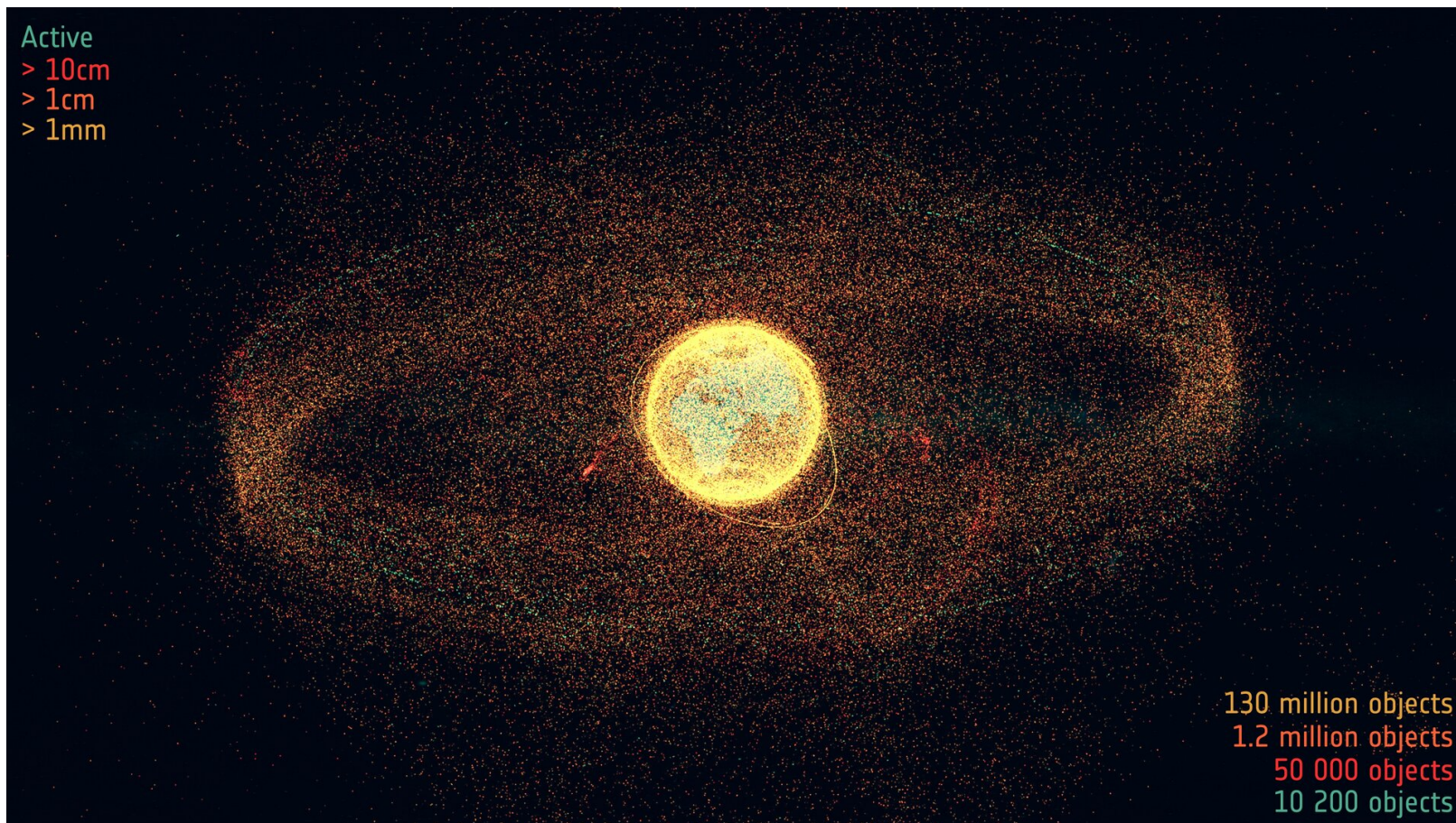


Figure 4. Exclusion zones around FS P-MP receivers: red area represents flat terrain and green area represents actual terrain elevation. (a) Exclusion zone around FS TS; (b) exclusion zone around FS CS.

Current space situation



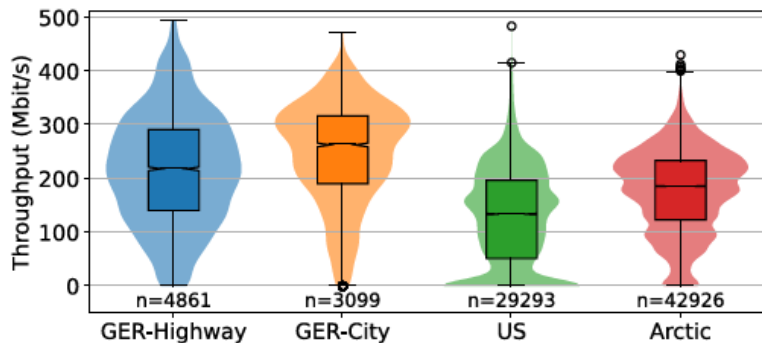
Satellite crowding in the space

[https://www.esa.int/Space_Safety/Space_Debris/ESA_Space_Environment_Report_2025]

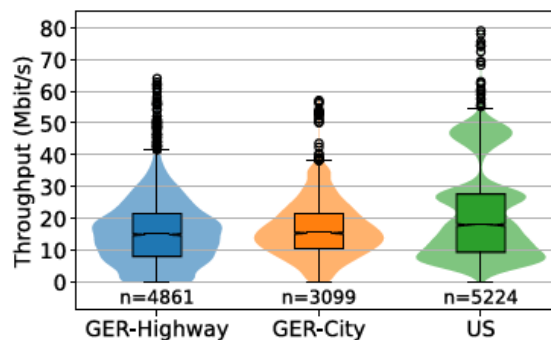
Starlink=9600;
20-25 Gb/s for each
satellite;
50-500 Mb/s for user
(downlink)
10-20 Mb/s upload

Oneweb 650;
8-10 Gb/s;
50-200 Mb/s (dw);
10-20 Mb/s (up)

Drive tests for Starlink Performance

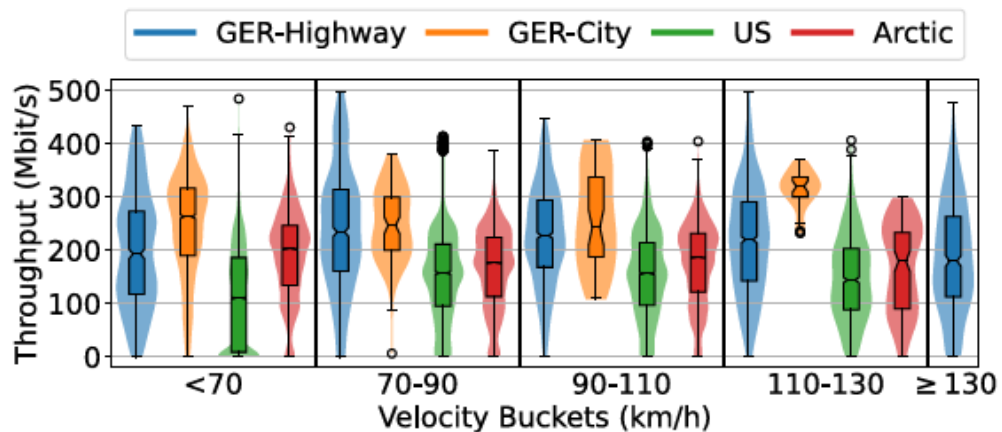


(a) Downlink

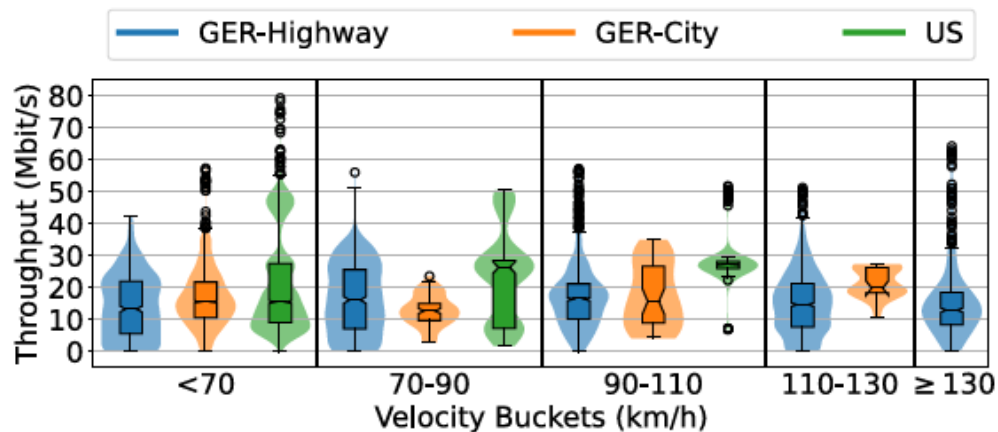


(b) Uplink

D. LANIEWSKI et al. Measuring Mobile Starlink Performance: A Comprehensive Look, IEEE Open Journal of the Communication Society, vol 6, 2025.



(a) Downlink



(b) Uplink

Use Case Characterization

Use Case Category	Specific service	Latency	Reliability	Availability	User Data Rate	Architecture
Urban/Suburban area	Traffic offloading in event scenarios	≤500 ms	99.9%	N.A.	1–10 Mbps	LEO/GEO Satellite-based; 3D Single/Multi-Connectivity
Rural/Remote area	Coverage of non-connected areas	≤500 ms	99.9%	N.A.	1–10 Mbps	LEO/GEO Satellite-based; 3D Single/Multi-Connectivity
	Firefighters / Voice communication	≤100 ms	99.9%	N.A.	100–300 kbps	3D Single/Multi-Connectivity
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	Interactive Aerial Telepresence	≤10 ms	99.9%	N.A.	1 Gbps (video) / 10 Mbps (commands)	Drone-based Relay
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Drones for Delivery	Very critical video	≤10 ms	99.9%	N.A.	Very high (20 Mbps up to 1 Gbps)	3D Single-Connectivity
IoRT	Very critical video	≤500 ms	95%	N.A.	1 kbps – 1 Mbps	Satellite-based
Maritime sector	Maritime broadband	≤500 ms	99.9%	N.A.	≥2 Mbps	Satellite-based; 3D Multi-Connectivity
	Autonomous vessels	≤10 ms	99.9%	N.A.	≥100 kbps → Mbps	Drone-based Relay
	Search & Rescue	≤100 ms	99.9%	N.A.	100–300 kbps	LEO Satellite-based
Telemedicine	X-ray screening	<1 s	100%	99.99%	1000 bits/s	LEO/GEO hybrid access (Satellite-based)
	CT Analysis	<1 s	100%	99.99%	10 Mbps	LEO/GEO hybrid access (Satellite-based)
	Red Cross	<1 s	100%	99.99%	3–4 Mbps	LEO/GEO hybrid access (IoT + voice analysis)
	Mobile Unit Red Cross	<1 s	100%	99.99%	10 Mbps	LEO/GEO hybrid access (mobile sensors)
	Smart Voice App	<1 s	Not required	99.99%	2 Mbps	Satellite-based (D2D LEO constellation)

G.Piro «Rethinking Global Digital Connectivity with Non-Terrestrial Networks» Restart Planary January 19-21, Rome 2026



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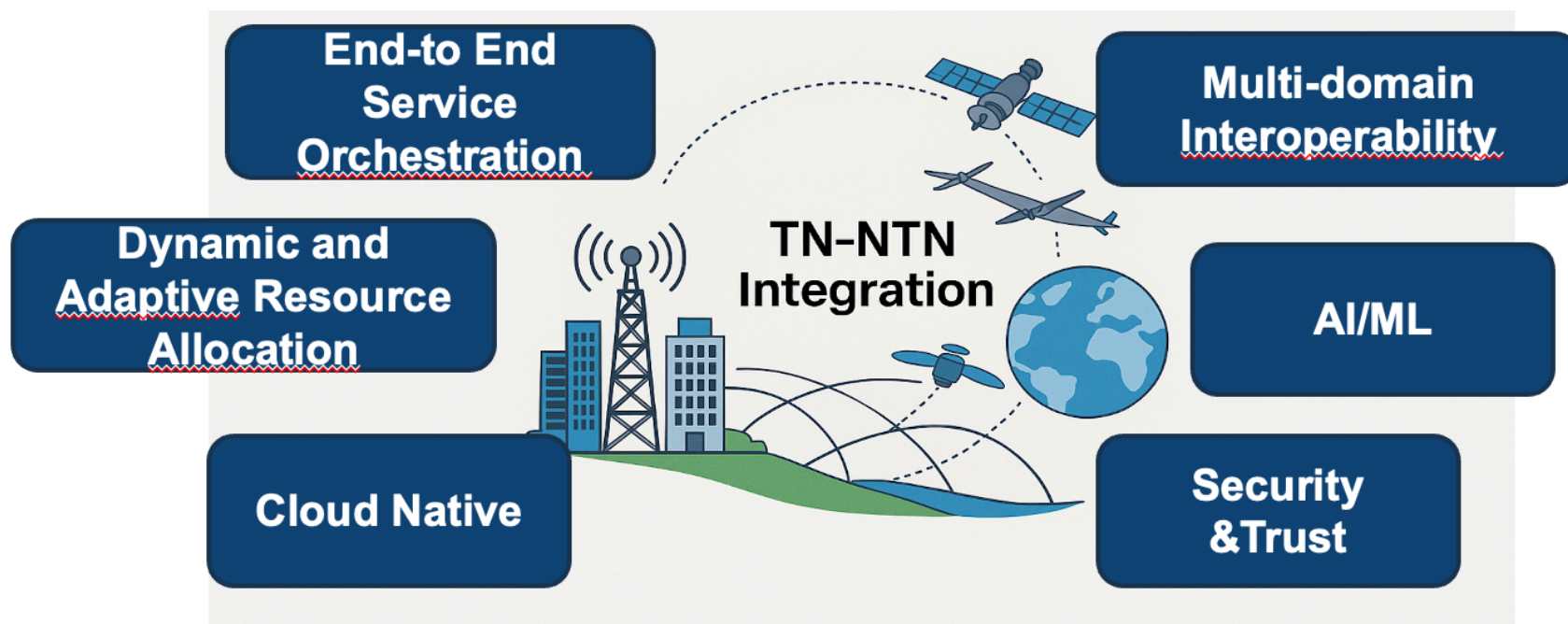
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Novel approach to Management & Orchestration for TN and NTN Integration



DIA SUMMIT Today: Where and How Data Analytics and AI in TN-NTN?



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Advanced Analytics, Intelligent Functions and Cloud Native for TN–NTN Orchestration

Current Standardization:



Advanced Analytics

- Cross-domain visibility
- Proactive resource mgmt
- Service assurance



Intelligent Elements

- 3GPP
MDAF – management analytics
NWDAF – core intelligence
- O-RAN
RIC – RAN optimization

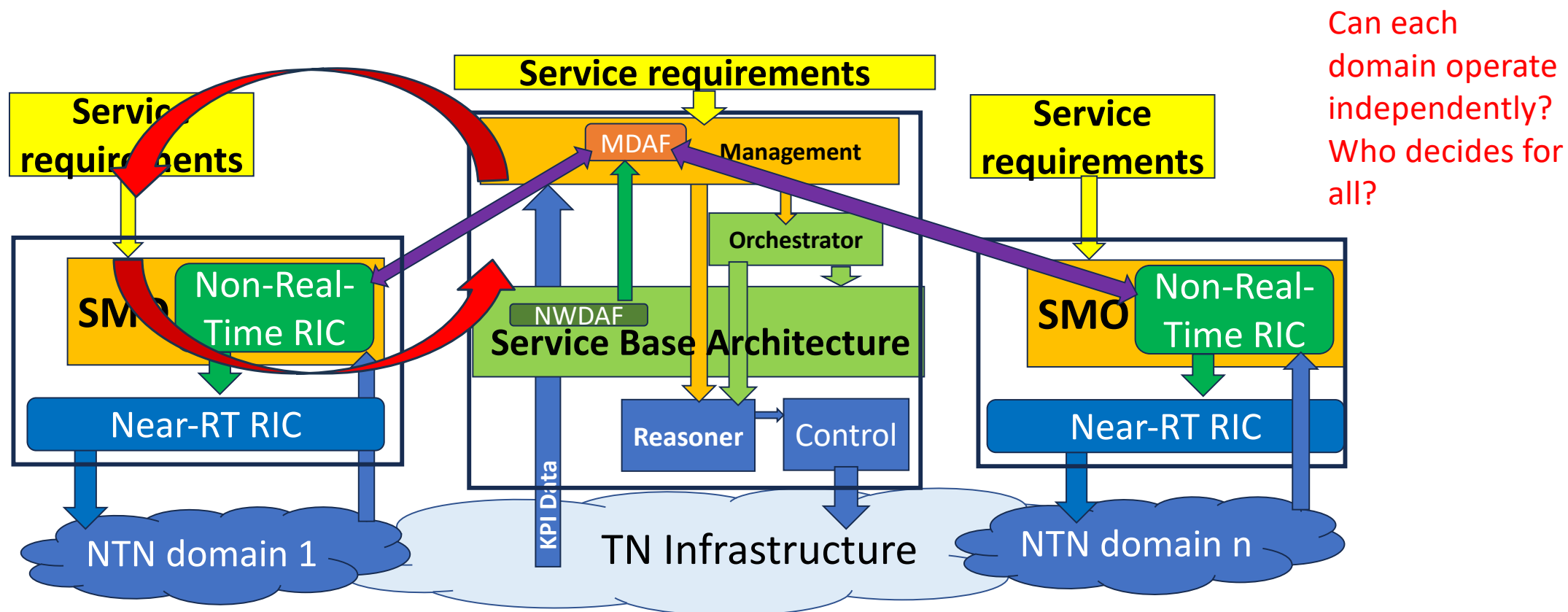


Cloud-Native Approach

- Microservices & containers
- Edge/cloud continuum
- Zero-Touch Mgmt (ETSI ZSM)

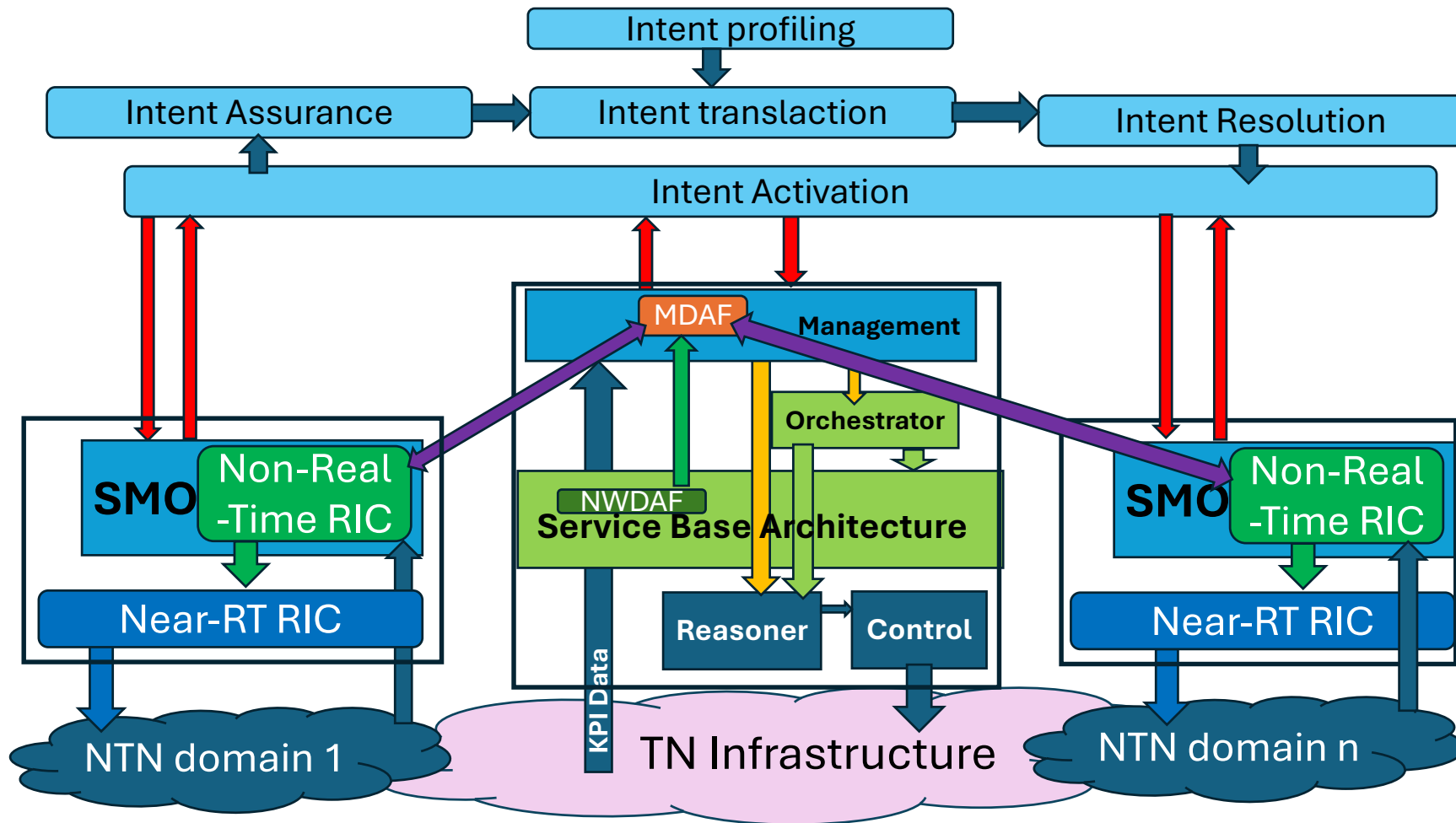
- The detailed design of functional components, interfaces and cloud aspects remains under study in standardization bodies, in line with the ETSI Zero Touch Management (ZSM) vision of AI-driven automation.

Management & Orchestration for TN and NTN Integration according to current standardization



M. Settembre, et al "Towards 6G architectures for leveraging synergies between artificial intelligence and networking," in Proc. AEIT Annual Meeting 2025, Amantea, Italy, Sept. 10–12, 2025

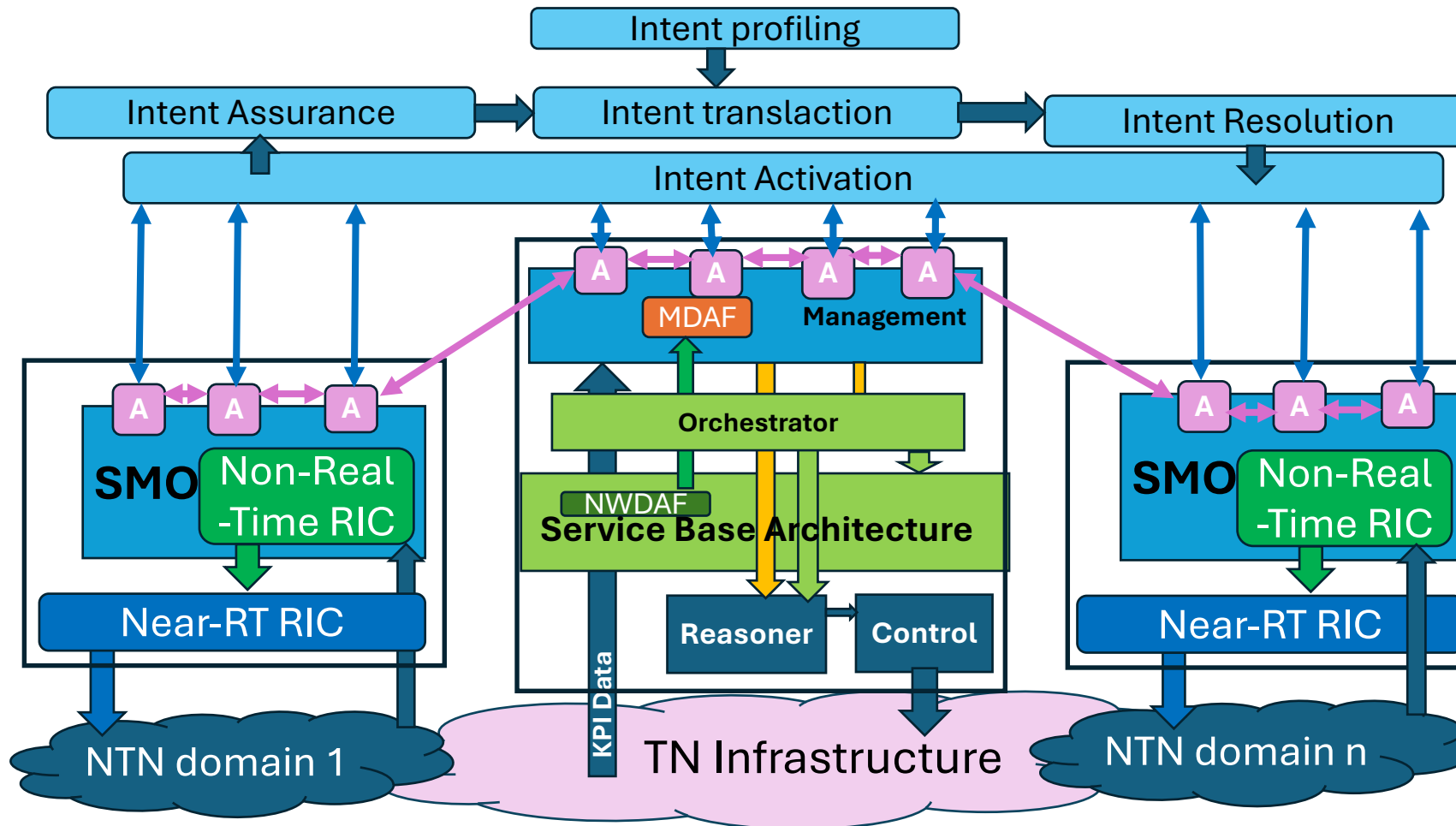
Intent Base Network approach



Starting from
TM Forum
2022)
Zero touch by
the loop in
Intent level

Large Language
Model (LLM) very
useful for Intent
level

Intent Base Network with Agentic AI



ETSI, “Zero-touch network and service management (ZSM); Study on the utilization of agents in autonomous networks,” ETSI GR ZSM 020 V1.1.1, 2026

Communication between agents, using : Model Context Protocol (**MCP**) Agent to Agent (**A2A**), Communication between agents and external tools and services

Security issues



- Security issues (confidentiality, integrity and availability) must be considered in the whole TN-NTN networks
- Satellite vulnerability: natural problems, kinetics attack, malicious attacks, as jamming, eavesdropping, hijacking, and spoofing,
- Resource constraints: reduced-in-size satellites sets limitations in terms of storage, power, and processing capability. This restricts the ability to implement security measures, such as strong cryptographic techniques, firewalls that require significant resources
- Dynamical topology: problems for update of authentication policy and renegotiation of IPsec / TLS tunnel.
- Orchestration for all the T-NTN networks requires high security approaches



Security countermeasures



- **Physical layer:**
 - multi beam satellite secure communication, directional antennas and spread spectrum techniques can help to resist against jamming attacks,
 - THz band in LEO Inter-Satellite Links (ISLs)
 - FSO can adopt security methods more reliable than RF ones
- **Authentication**
 - The 3GPP has developed a unified authentication framework for mutual authentication of terminals. Is it suitable for NT?
- **Secure Protocols**
 - Secure transport protocols (mainly based on TCP) are suitable for NT? New seamless handover scheme based on the predictability of satellite orbits, limiting service interruption due to periodic disconnection of satellite links.
- **Future (Quantum thread)**
 - Quantum Key Distribution (QKD) vs Post Quantum Cryptography



Conclusions

- Presented a **high-level vision** for TN–NTN environment from ITA-NTN project
- Addressed some key aspects: **use cases, architectures, spectrum exploitation, performance, security**
- First steps only – a foundation for **future integrated 6G networks**
- *Management & Orchestration*
 - i.e. AI necessity
- Where AI and data Analytics?
- Current standardization solutions
- Towards Zero touch Management
- Agent AI-Intent Base Networks
- “*The devil is in the details*” → much work remains to turn vision into reality
- Security aspects



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Thank you for your attention

Francesco Matera



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Work started in the framework of the ITA-NTN RESTART Project and continued under the agreement with the Italian Ministry of Enterprises and Made in Italy (MIMIT), dated 1 August 2024(CUP:B85G24000170001)