NETWORLD EUROPE

Strategic Research and Innovation Agenda Webinar
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NON-TERRESTRIAL NETWORKS (NTN)

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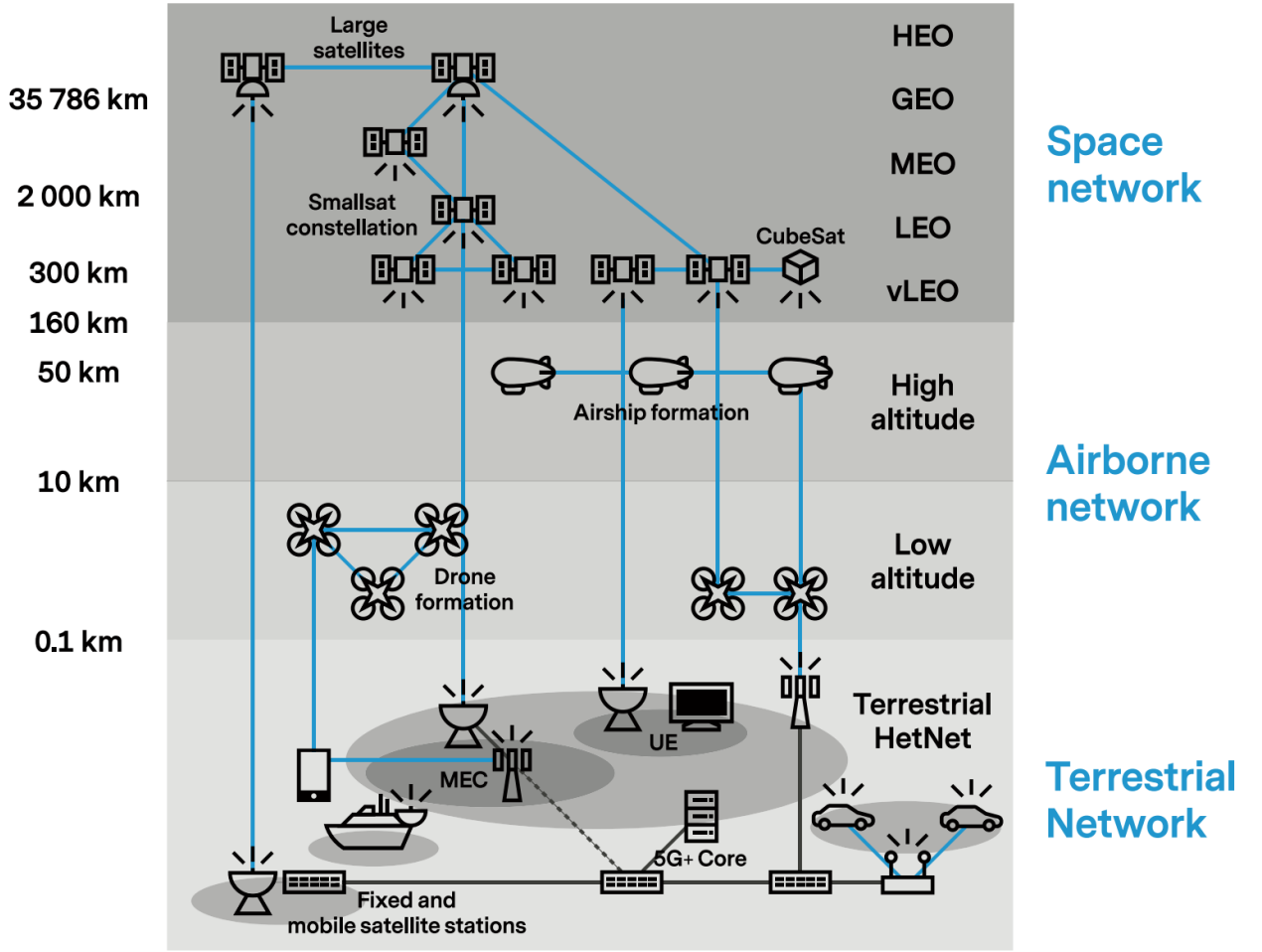
OVERVIEW

- SRIA2022 Tech. Annex – Non-terrestrial networks and systems section (pp. 201-241)
- Originated at VFCS 2017 and in SRIA 2018 as Satellite Communications
- Substantially extended to Satellite Communications in the SRIA 2020 version
- SRIA 2022: updated and extended version of SRIA 2020 to reflect the technology evolution
- Huge effort from the NetworldEurope-SatCom WG:
  - More than 20 contributors
  - bi-weekly Telcos across February and May and offline checkpoints until the final version

NTN PART OF A NETWORK OF NETWORKS

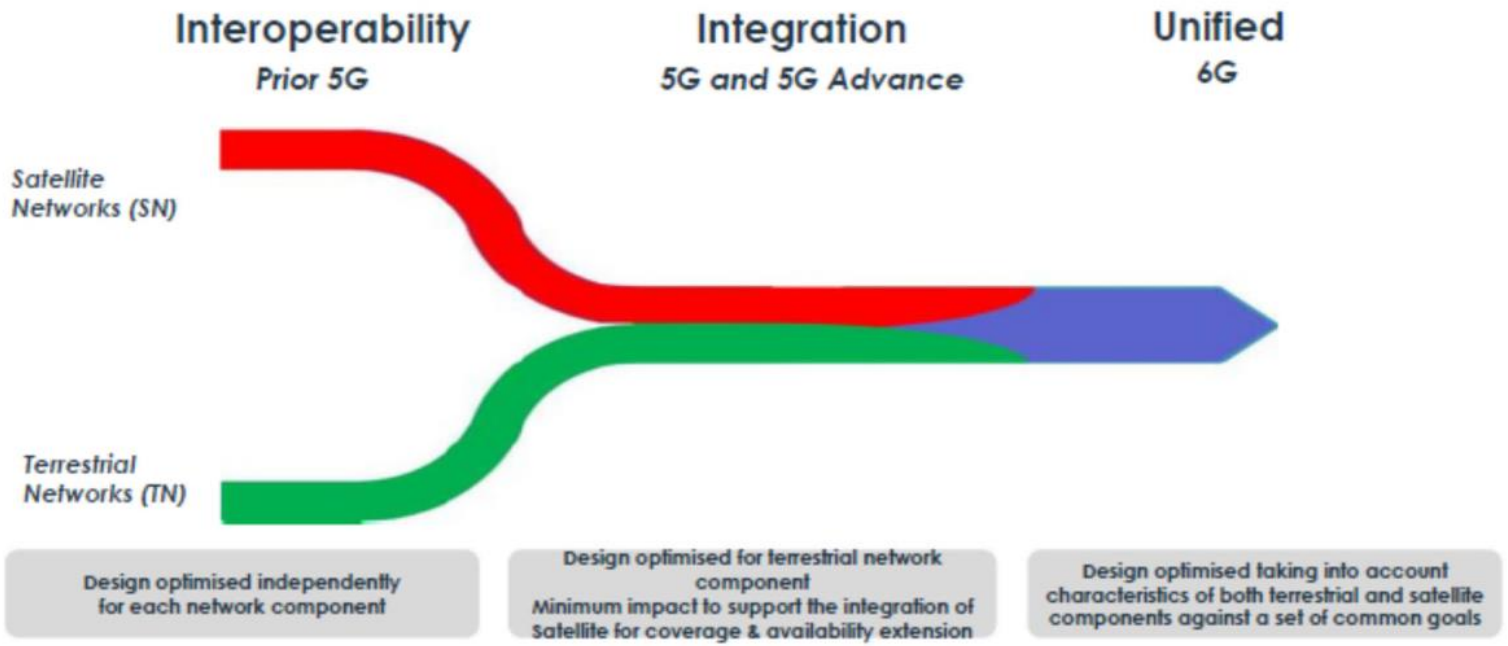
- 6G network expected to be **hybrid network of networks** from **short range and ultra-high capacity** to widest coverage via a new space network dimension
- NTN to play a pivotal role to fulfill all stringent 6G requirements, in terms of anytime, anywhere, any-device (**ATAWAD**) connectivity requirement
- **Evolution of NTN technology to converge with TN domain and close the performance gaps** emerged during 5G conception phase



M. Höyhtyä, M. Corici, S. Covaci and M. Guta, "5G and beyond for new space: Vision and research challenges," ICSSC-2019, pp. 1-16, doi: 10.1049/cp.2019.1236

NTN AS A GLUE TOWARDS UNIFIED 6G

- NTN aimed at convergence with TNs through:
  - integrated systems,
  - commercial products
  - Converged standardisation plans (as part of 3GPP)
  - Sustainable ICT support



NTN AS KEY COMPONENT IN 6G

- NTN in 6G as a dynamic and multi-folded network architecture building on diverse and converged network assets:
  - **Multi-layer network** which adds satellites in GEO, MEO and LEO to lower altitude HAPS and even lower aerial devices such as drones;
  - **Diverse orbits** such as HEO (highly-elliptical orbit, see Molniya) and VLEO (Very-Low Orbits, also mentioned above as vLEO) might be considered too.
  - The network architecture connecting these components will be **service dependent** as some architectures will better suit the requirements of specific services.
  - The **network functions** can also be **distributed** amongst the entities to optimise performance.
  - **In all cases we will have a highly integrated E2E cross-network system.**

KEY CHALLENGES FOR NTN IN 6G

- Unified T/NTN architecture
- Full network integration of all layers in a 3D SDN Network
- Direct connectivity to smart phones, outdoor and light indoor and in vehicle
- Ultra Low Latency support for vertical sectors
- Ultra-accuracy of positioning and timing

- Integrated and flexible Air Interface for multi services.
- New spectrum and sharing across the network components
- Supporting massive IoT
- Solving the problem of massive antennas in space

KEY CHALLENGES FOR NTN IN 6G

- Embedding AI in network and RAN
- Orchestration of 3D multi-level NTN networks
- A new IP for space networks

- Merging networking and computing -not just at the edge
- Edge computing in space

- Providing Security across the network- elements
- QKD and blockchain in integrated TN/NTN networks

RESEARCH THEMES

- **Architecture and System-Level Aspects**
  - Multilayer Architecture, Satellite-as-a-Service and Ground-Segment-as-a-Service, Autonomous Networking, Mobility Management, Autonomous Positioning
- **Air Interface**
  - Waveform design, Multi-antenna solutions, Integrated Communications and Sensing, NG-MAC and –RRM
- **Network of Networks**
  - Dynamic NG-RAN functional splitting, cognitive-based intent-based networking, AI-based network management and slicing, content/service-oriented networking, non-IP networking in space

RESEARCH THEMES

- **Edge Computing**
  - Multi-layer architectures for Edge Computing service deployment, In-network computation in space, resource orchestration
- **Security on the 6G 3D Networks**
  - QKD on Free-Space NT Networks, Federated Network of Blockchain, End-to-end security for integrated TN/NTN networks

TIME PERSPECTIVE

	2025	2028	2031
QoS levels to maritime and aeronautical users	Unacceptable	Acceptable	Satisfactory
Ultra-flexible offered capacity. This key value refers to the satellite fined granularity to offer the intended capacity where needed over the coverage area.	Some of the satellite capacity remains with no clientes	Most of the terminals have access to satellite capacity	Satellites are able to reconfigure its capacity to reach all terminals needs
Unfied chipset and telecom infrastructure	Software defined radio solutions are available for low data rates	Unified hardware-RF solutions available for NTN and TN	Same equipment for NTN and TN is provided by vendors
Seamless interoperability	Satellite access is ensured by the user with a dedicated interface	Users experience a faulty network when migrating from TN to NTN	User are not aware whether they are connected to a NTN or TN
Smartphone connectivity for voice and video	Smartphones can only send text uplink messages	Interactive voice communication is available	Full data uplink and downlink communication takes place
User-level service level accomplishment	99 %	99.9%	99.99%
Spectral efficiency	uplink 0.5 - 1 bps/Hz downlink 1-3 bps/Hz	uplink 0.5 – 1.5 bps/Hz downlink 1.5 - 4 bps/Hz	uplink 1 – 3 bps/Hz downlink 1.5 - 4 bps/Hz
Terrestrial and non-terrestrial handover delay	Few seconds to minutes	Less than a second	Perception of zero delay
Radio terminal power consumption	26 dBm	21 dBm	18 dBm
Network Architecture	Programmable Data Plane	Dynamic NG-RAN functional splitting	Orchestration of network slicing driven by AI

TIME PERSPECTIVE

	2025	2028	2031
Network Management/Orchestration	Orchestration for converged NTN -TN Infrastructures	Unified orchestration in 3D Networks	Intent-based network orchestration
Routing in Space	Traffic engineering and flexible IP forwarding	Semantic routing taking into consideration differentiated contexts	Service-centric routing able to support full convergence of networking and computing
Latency	Moderate reduction for non-real time services through proper NTN layer selection	Optimized latency-driven service deployment for reduced latency services	Seamless integration with TN aiming at automatically deploying services depend on the latency requirements
Autonomous service deployment	Reactive automatic service deployment based on user request	Proactive automatic service deployment based on user request	AI-driven multi-service deployment
Global coverage	Ground user global coverage with Edge Computing solutions through NTN connections	In-orbit services coverage with Edge Computing Solutions through NTN connections	Joint ground and in-orbit service global coverage through integrated in-orbit and ground Edge Computing solutions
Distributed Processing	NTN layers will be used as backup/ offloading facilities when ground nodes cannot satisfy user requests	NTN layers will be integrated with TN for providing distributed processing platforms for use requests	Transparent joint NTN/TN distributed platform solution for both ground and in-orbit service request
Space In- network computing	NTN nodes are used for remotely processing tasks	NTN and Space nodes are jointly used for remotely processing tasks	NTN and Space nodes have distributed in-network processing functions
Distributed Learning	NTN platforms can be used as centralized nodes for data collection during distributed learning	NTN nodes can participate to distributed learning algorithms executions	NTN nodes are integrated with TN for creating a unique distributed learning environment

TIME PERSPECTIVE

2025	2028	2031
Supporting critical data transmissions		
In 2025 there will not be any NTN that supports critical service	In 2028 at least emergency services from NTN to phone will be supported	In 2031 full critical services from NTN will be supported
Traffic load in secure networks		
In 2025 will not be traffic load with new paradigms of security	In 2028 50% of the traffic from NTN will support new paradigms of security	In 2031 90% of the traffic from NTN will support new paradigms of security
Revenue of companies that provide secure TN/NT		
In 2025 no revenue from new security paradigms introduced in NTN will be provided	In 2028 more than 50% of the revenues in NTN will be provided from new secure paradigms	In 2028 more than 80% of the revenues in NTN will be provided from new secure paradigms
Secrecy rate of the NTN communications		
20% increase of secrecy rate compared to not introducing them for 2025	30% increase of secrecy rate compared to not introducing them for 2028. (10% of increase respect 2025)	40% increase of secrecy rate compared to not introducing them for 2031. (10% of increase respect 2028)
Latency of NT network after introducing security constraints		
20% increase compared to not introducing new security measures for 2025	10% increase compared to not introducing new security measures for 2028 (50% of reduction)	5% increase compared to not introducing new security measures for 2031 (50% of reduction)
Recovery time after suffering an attack in an NT network		
1h of recovery time for 2025	30' of recovery time (50% of improvement) for 2028	15' of recovery time (50% of improvement) for 2031
False alarm/Detection probability of being attacked		
90% of Detection Probability of being attacked for 2025	99% of Detection Probability of being attacked (10% of improvement) for 2028	99.9% Detection Probability of being attacked (10% of improvement) for 2031

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THANK YOU FOR YOUR ATTENTION

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