ETSI Conference on
Non-Terrestrial Networks,
A Native Component of 6G

6G SmartSat

# Networking architectures for multi-layered non-terrestrial networks

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# 6G SmartSat - Overview

## Study Background

- Converged multi-layer **terrestrial-satellite network infrastructures** promise a solution for **ubiquitous, scalable and flexible connectivity**
- The **multi-layer non-terrestrial network (ML-NTN)** part poses challenges to the transport layer due to continuous topology changes

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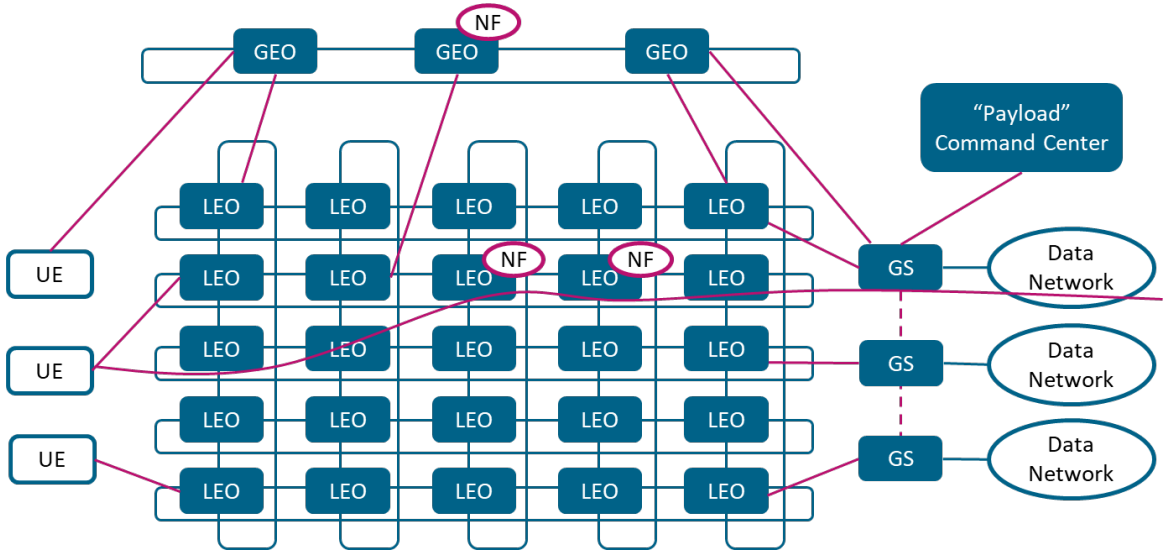
## Study Objectives

- Design and validation of a **routing solution** taking into account the continuous yet predictable topology changes considering Layer 2, Layer 2.5 and/or Layer 3 + a semantic routing layer
- **Interconnection** of the proposed ML-NTN **with terrestrial networks** to be able to operate the space infrastructure as IaaS for the terrestrial network operator
- A practical **testbed** demonstrating and validating the end-to-end system



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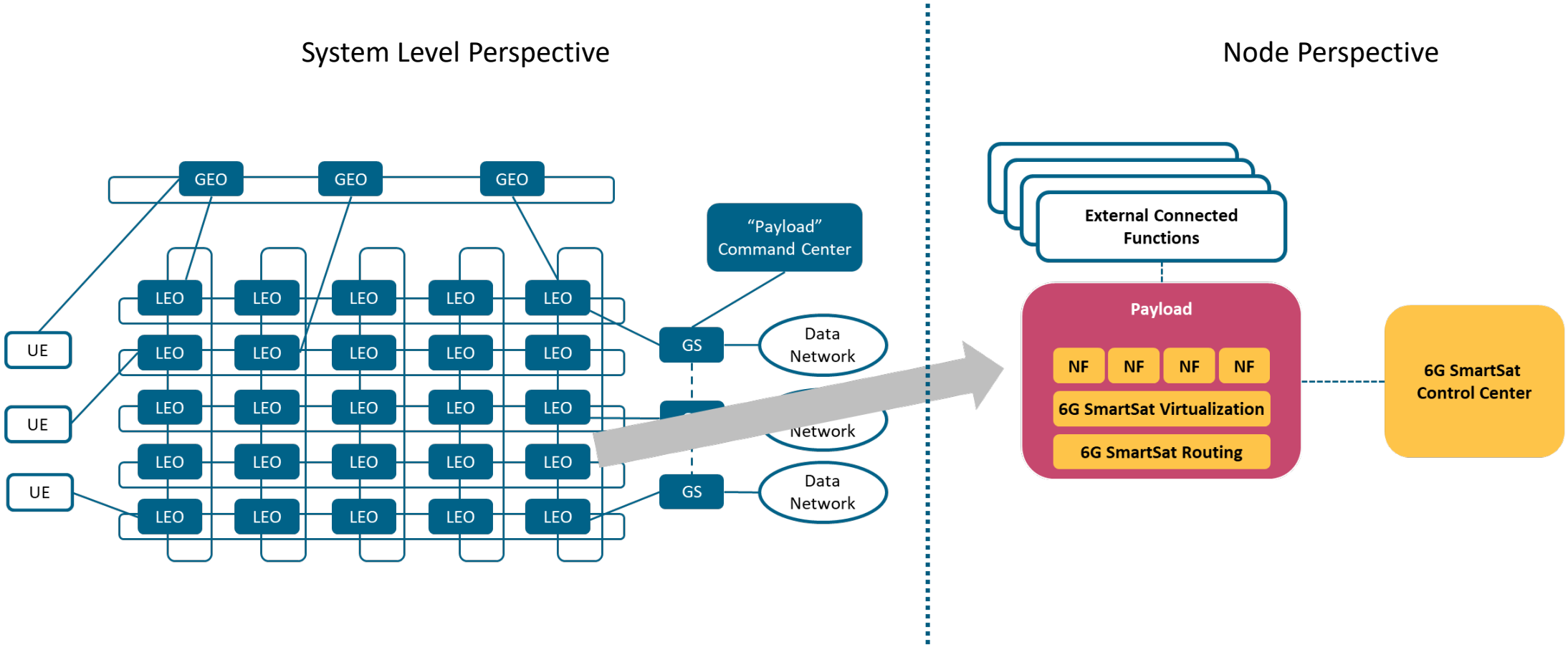
# Semantic Routing

- By understanding the content of the data, semantic routing enables more intelligent and efficient routing decisions, with significant benefits for:
  1. Enhanced Quality of Service (QoS): Semantic routing can prioritize critical data based on its content, ensuring better QoS for important applications or services. It enables optimized routing paths that minimize latency, packet loss, and jitter.
  2. Context-Aware Routing: Semantic routing considers the specific context or requirements of the data, such as its intended destination, user preferences, or security constraints. This enables personalized routing and tailored services.
  3. Efficient Resource Utilization: By leveraging semantic information, routing decisions can be optimized to utilize network resources more efficiently. This leads to reduced network congestion and improves the overall network performance.
  4. Improved Scalability: Semantic routing allows for better scalability in large and complex networks. By considering the content of the data, it can dynamically adapt to network conditions and distribute traffic intelligently.

# Concept



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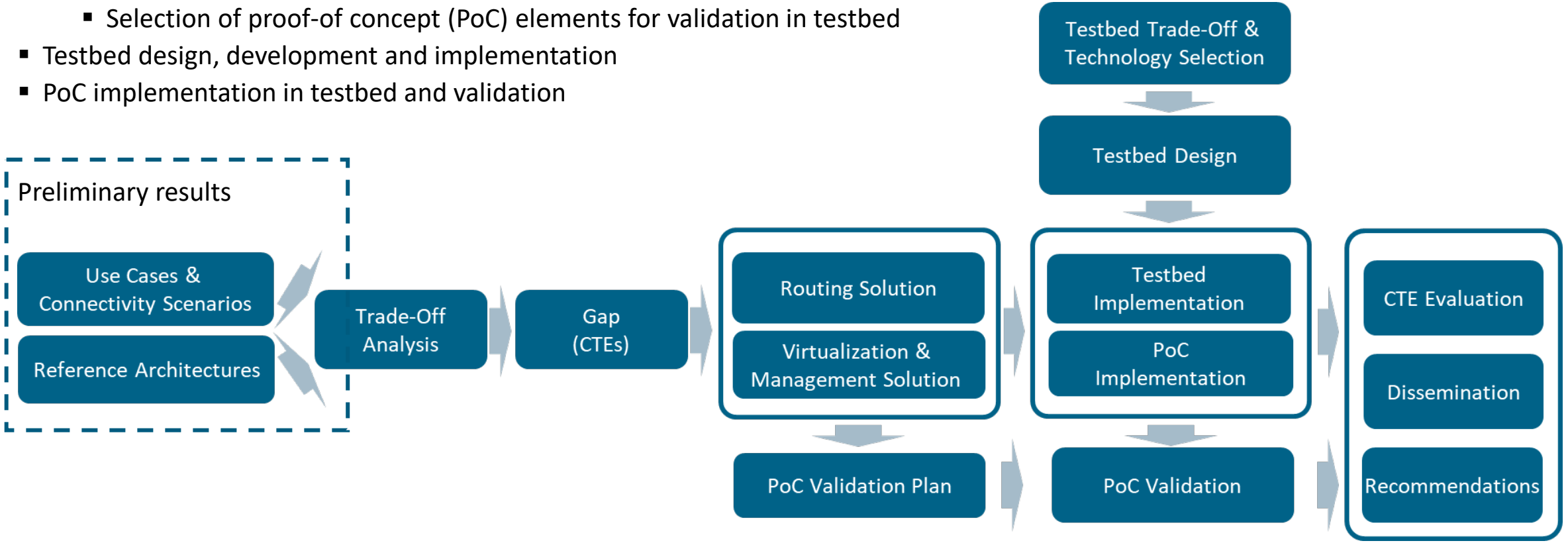
# Approach

- Use case analysis leveraging results from previous projects
- Reference architecture for ML-NTN system as basis for network model and simulation
- Trade-off analyses to identify gaps and critical technology elements (CTE)
- Development of semantic routing solution and virtualization & management solution
  - Selection of proof-of concept (PoC) elements for validation in testbed
- Testbed design, development and implementation
- PoC implementation in testbed and validation



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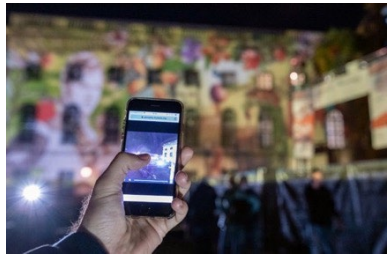
# Use Cases and Connectivity Scenarios

1. **Mobile Broadband Use Cases –** NTN for extending or filling in for terrestrial network services

- **Direct to Device**
- **Residential broadband**
- **Terrestrial link redundancy**
- **Backhaul for terrestrial infrastructures**
- **Airborne and space borne infrastructure backhaul**

**2. Private Network Use Cases –** extension of current and planned satellite-oriented cases addressing mostly business customer

- **Commercial aviation and maritime**
- **Commercial industrial and logistics**
- **Public protection (air/land/sea)**
- **Government and public sector**
- **Automotive**

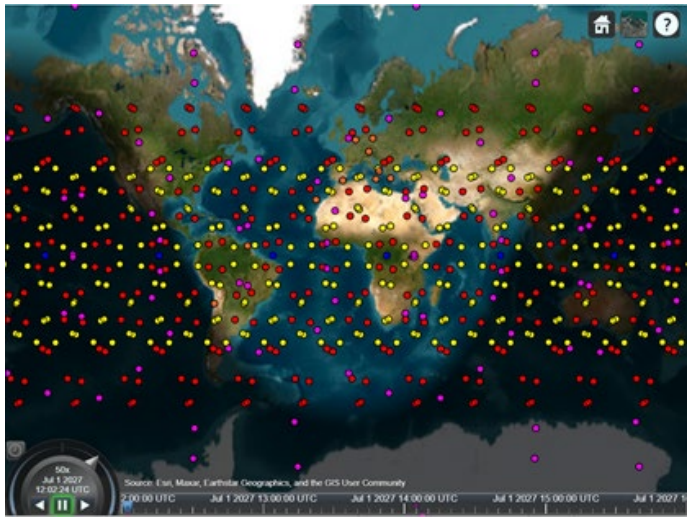


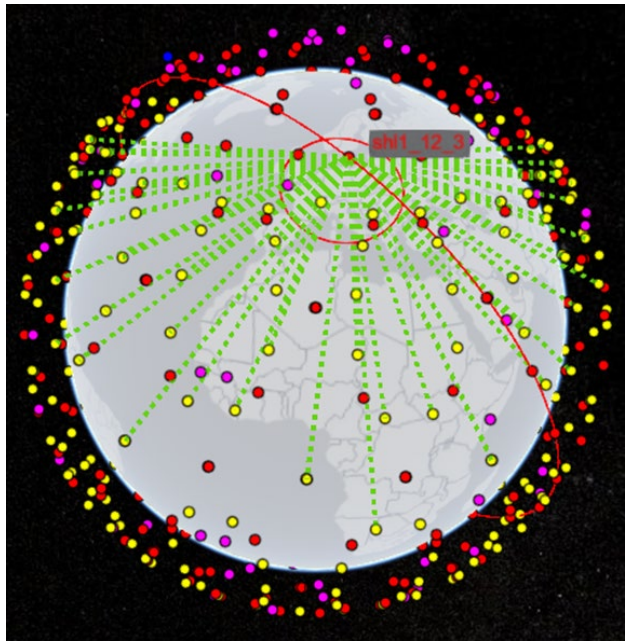


Objective in this project is to derive **functional requirements** of those use cases and verticals on the **transport layer** and a **traffic model** and scenarios to be implemented in the **network simulation**.

# Reference constellation example

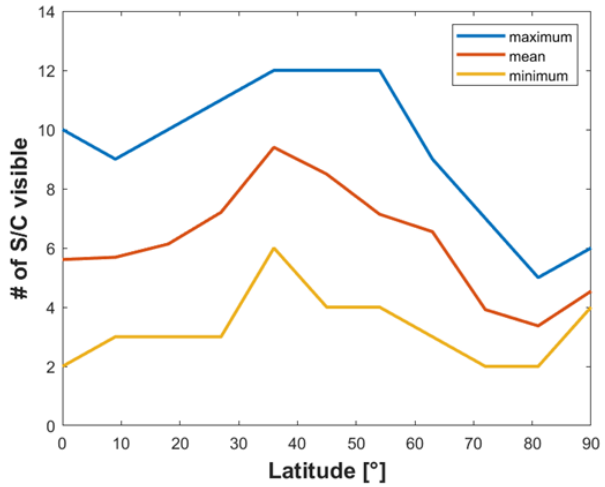
Example multi-layer constellation with
- 3 LEO layers with 672 satellites
- 1 GEO layer with 6 satellites
- Optimized inclinations for number of satellites over European latitides





Example evaluation of possible cross-layer links:
Many options available with different
- Duration of the link
- Link distance

→ Establish decision criteria when it makes sense to establish a cross-layer link
→ Optimize routing through the resulting dynamic network topologies



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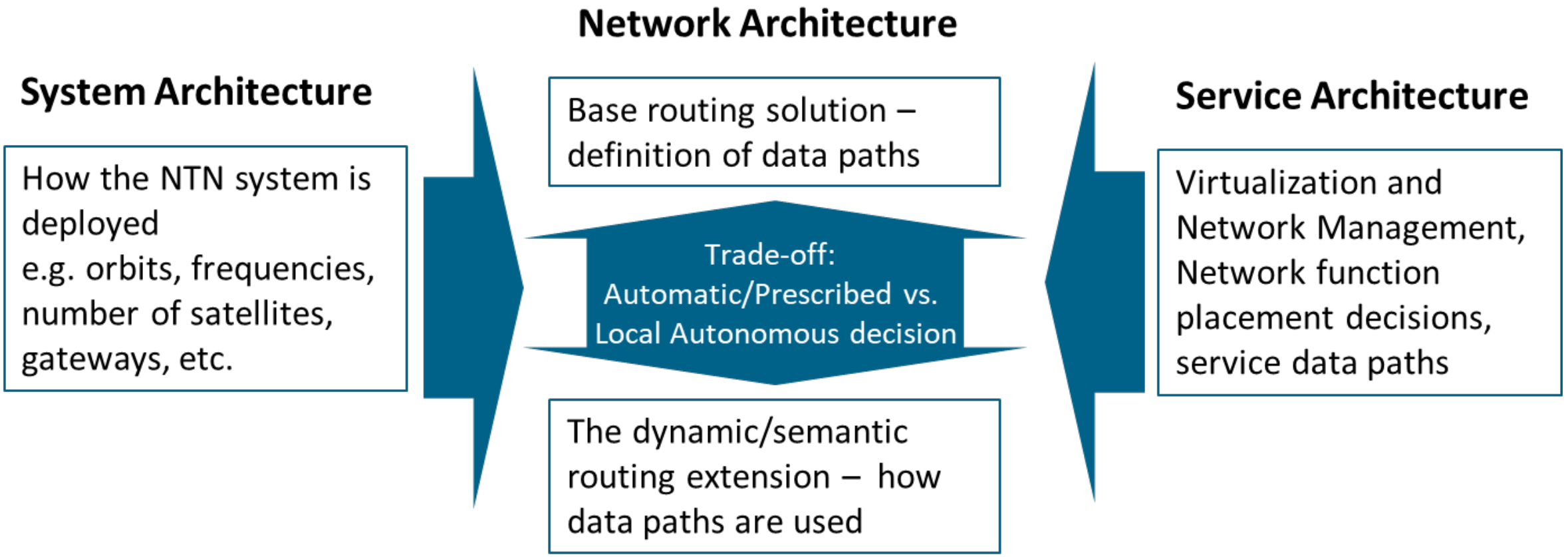
# Reference Architecture



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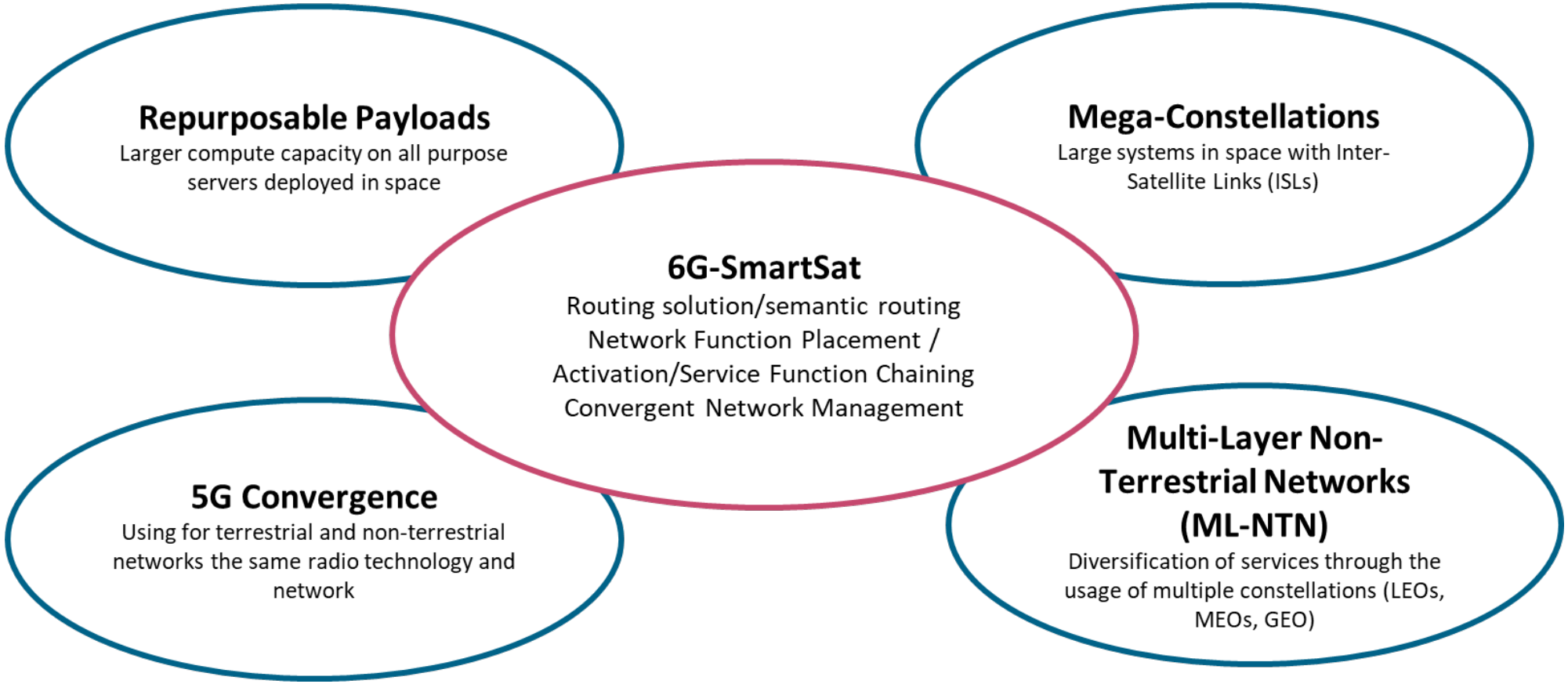
# Conclusion – 6G SmartSat in a nutshell




In **6G SmartSat**, we investigate new **network architectures** driven by major current trends in satellite communications and related technologies towards a **future converged satellite-terrestrial infrastructure**.



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