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

Intelligent satellite payloads as enablers for 6G

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AIRBUS

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5G-IS Space Infrastructure

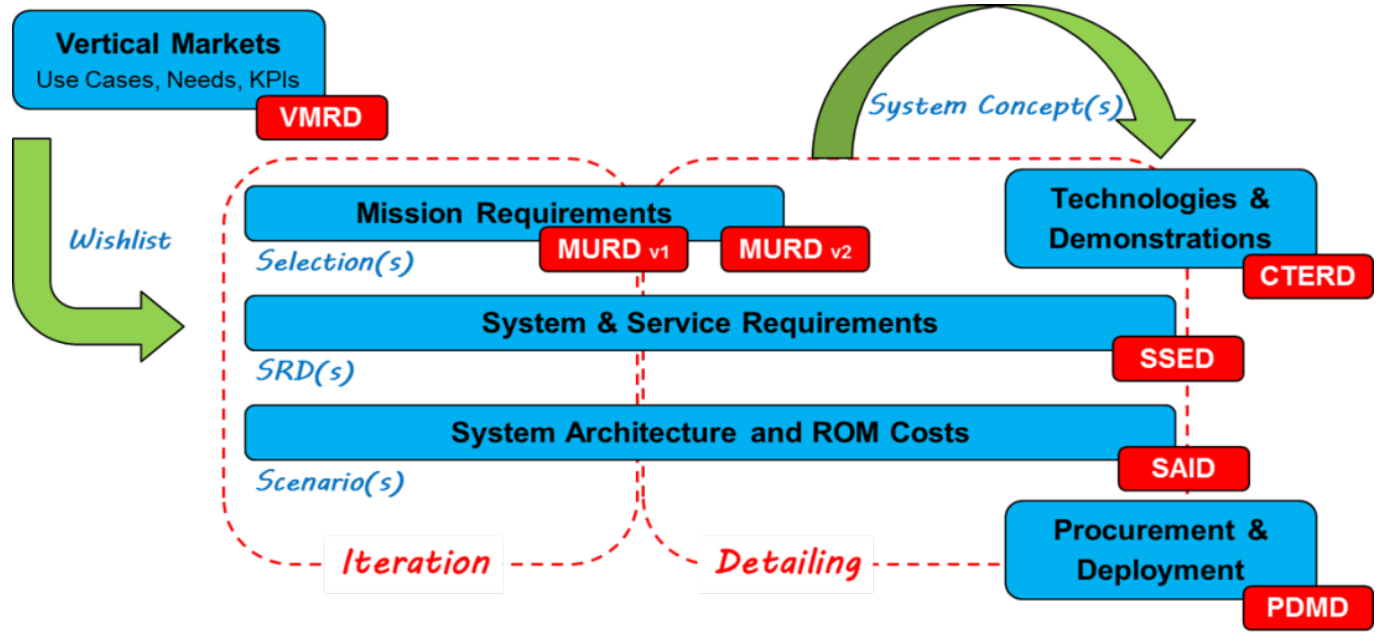
5G space-based Infrastructure Study – Overview

Study Objectives

- Assessment of vertical markets and use cases
- Space-based 5G NTN infrastructure concepts for mid-term (2025 – 2030) and long-term (beyond 2030) scope
  - Mission and User Requirements
  - Architecture and Implementation options
  - System and Service Requirements
- Critical technology elements with suitable development paths and demonstrations
- Recommendations for sound deployment including programmatics and financials

AIRBUS
Fraunhofer IIS
EURESCOM
Fraunhofer FOKUS
der Bundeswehr Universität München

July 2021 – July 2022 …



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5G-IS Space Infrastructure

5G-IS Automotive Extension – Overview

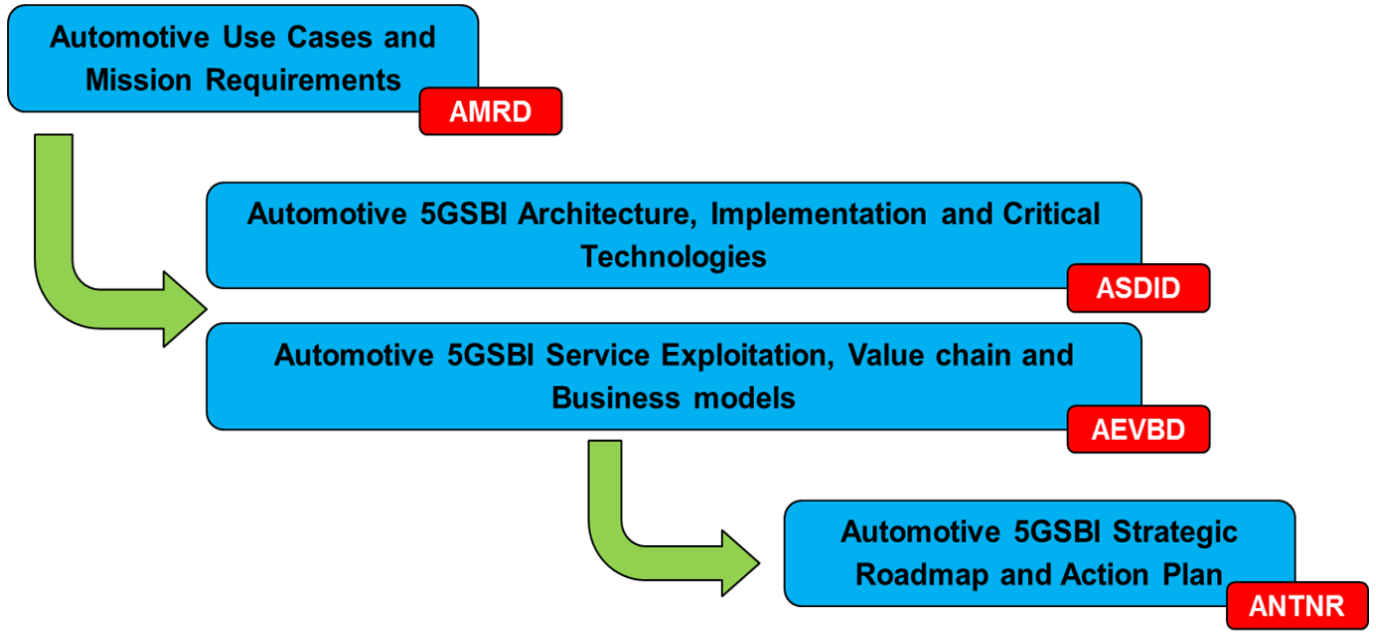
Extension Study Focus Areas

- Identification of Automotive NTN Use Cases
- Core Architecture and Technology Elements
- Value Chain and Business Models
- Strategic Roadmap and Action Plan

- With support (contributed in kind) from

AIRBUS, Fraunhofer IIS, EURESCOM, Fraunhofer FOKUS, Universität der Bundeswehr München

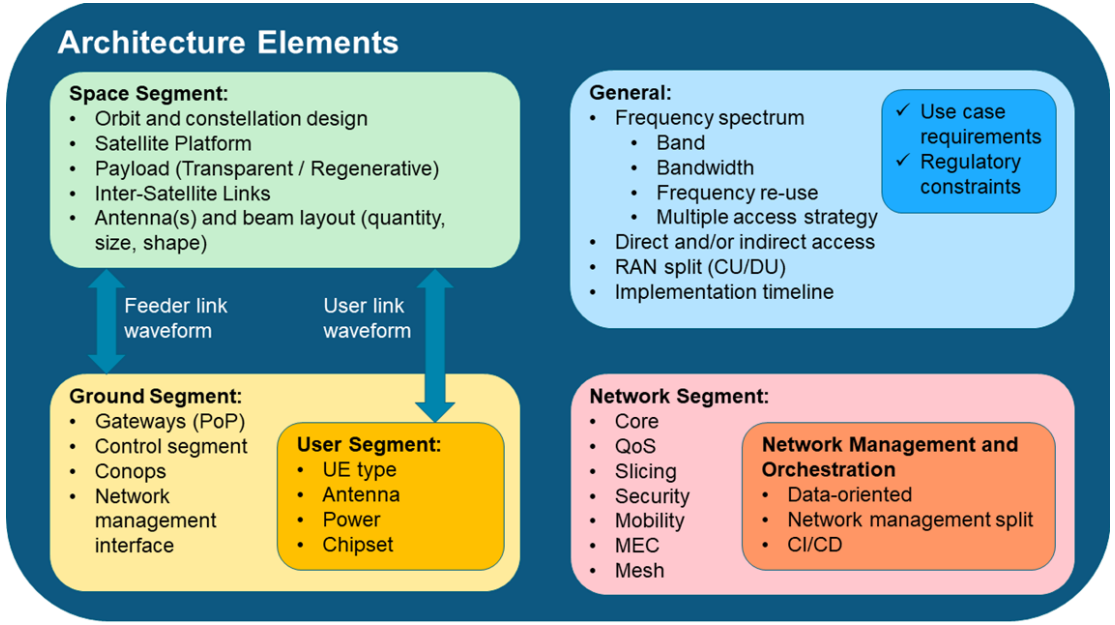
Sept 2022 – Feb 2024

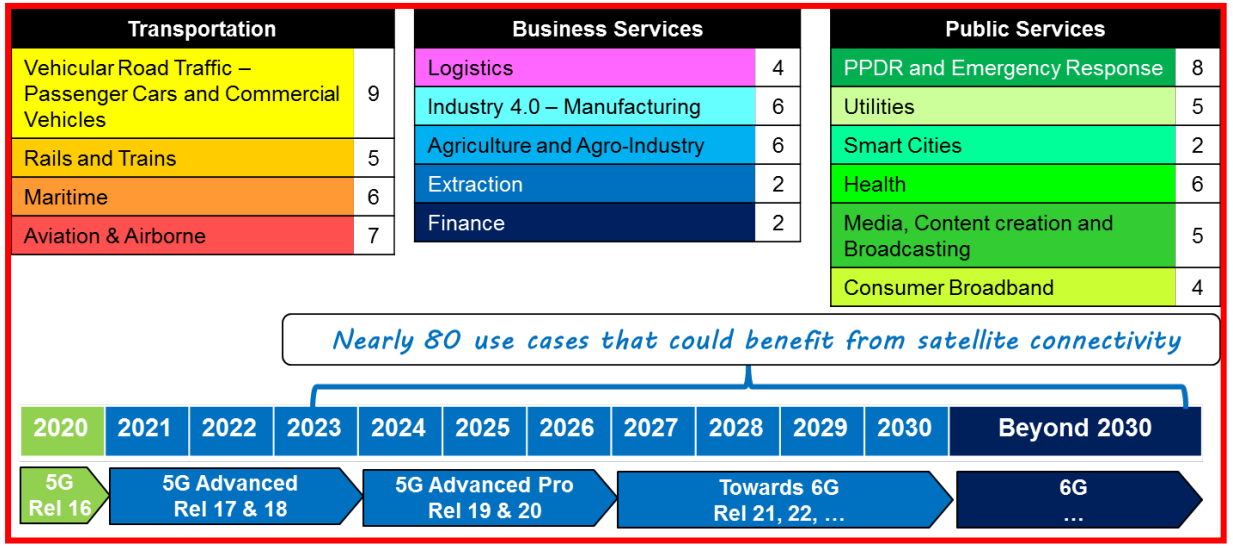


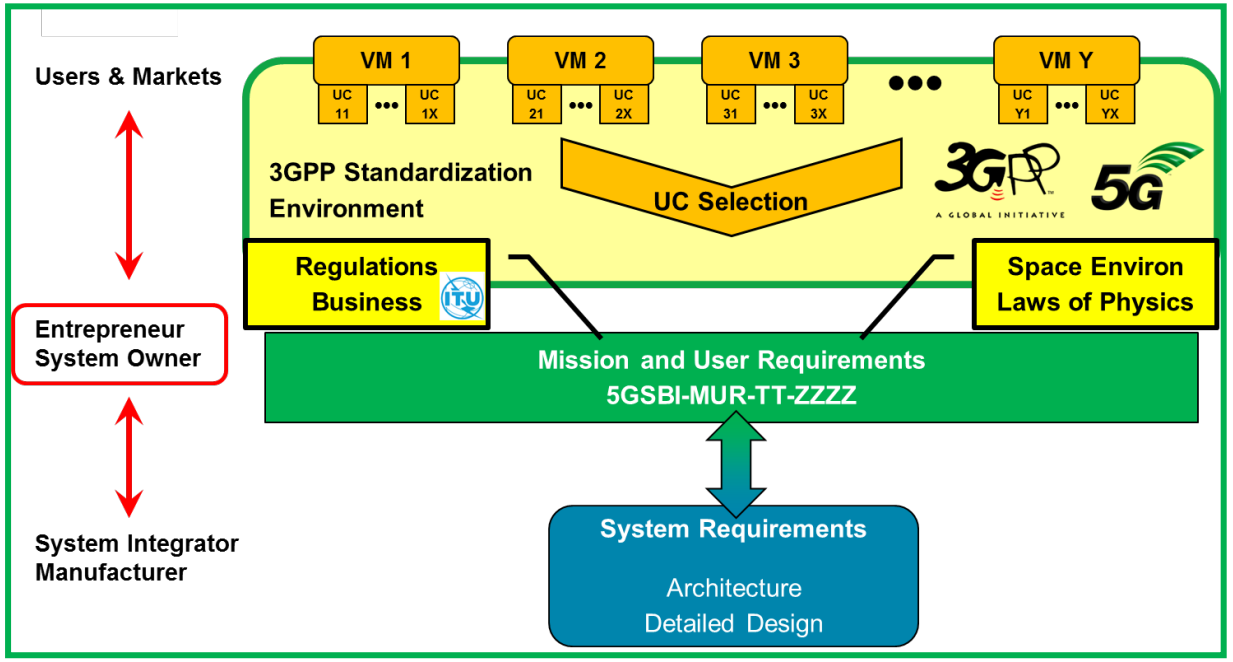
5G-IS Space Infrastructure

Major 5G-IS Results

- **Portfolio of vertical markets and associated use cases that benefit/require from continuous, ubiquitous and scalable (i.e. satellite) connectivity**
- **General framework for Mission and User Requirements – specialized to a tangible, ambitious mid-term (operational 2028) and a visionary long-term scenario**
- **Compilation of architecture elements and options as well as mid-term implementation scenarios**







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5G-IS Space Infrastructure

Major 5G-IS Results – 2

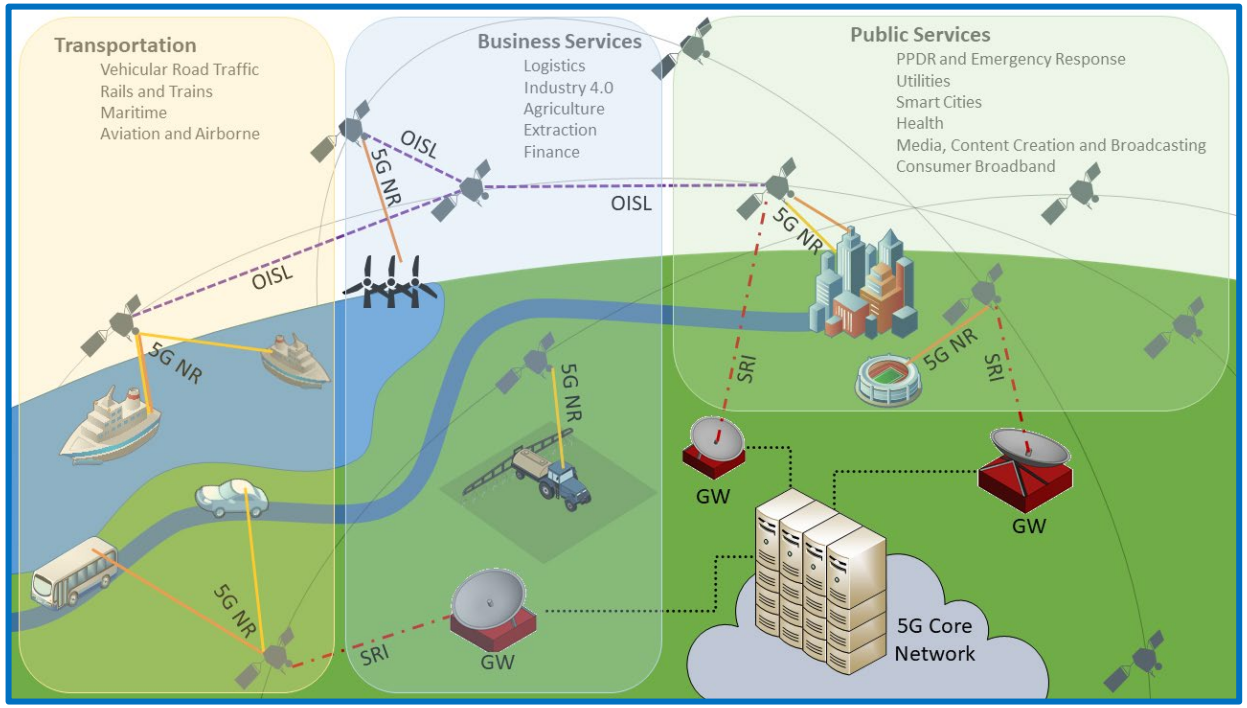
- **Technology Elements with prioritized technology development steps resulting in a conclusive demonstration roadmap**
- **Assessment of simple cost framework and analysts' expectations for 5G NTN revenues**
- **Fully TN/NTN integrated E2E system architecture with multi-layer (3D) mesh space-based infrastructure**

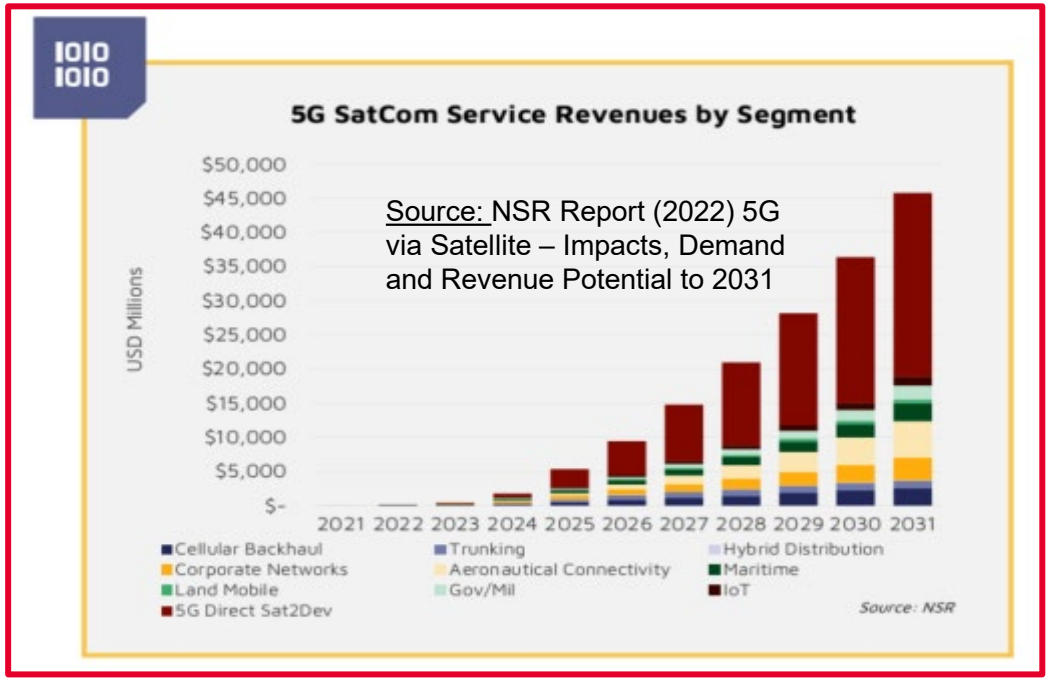
Space Segment
- Software defined flexible satellite
- Payload energy efficiency
- 5G TN/NTN routers in satellite
- 5G regenerative satellite payloads
- DRA payload antennas

Auxiliary Technologies
- New launcher capabilities
- Inter-satellite links and optical comms
- Very High Throughput Satellites (VHTS)
- High-Altitude Pseudosatellites (HAPS)
- Physical layer security

Ground Segment
- Ground segment diversity
- Dynamic frequency management
- „Best" access selection
- 5G TN/NTN network management layer
- Autonomous demand driven ground control center
- Software defined gateways
- 5G TN/NTN routers on ground
- UE integration and flat panel antennas
- Modems 5G NTN Chipsets

Network Segment
- Seamless (over-the-air) updates with remote attestation
- Distributed network management
- E2E integrated data driven network control/management/orchestration
- 5G security by design with new secure processor architectures
- NTN-Terrestrial convergent core network
- Asynchronous data exchange
- Subscriber profiling





Source: NSR Report (2022) 5G via Satellite – Impacts, Demand and Revenue Potential to 2031

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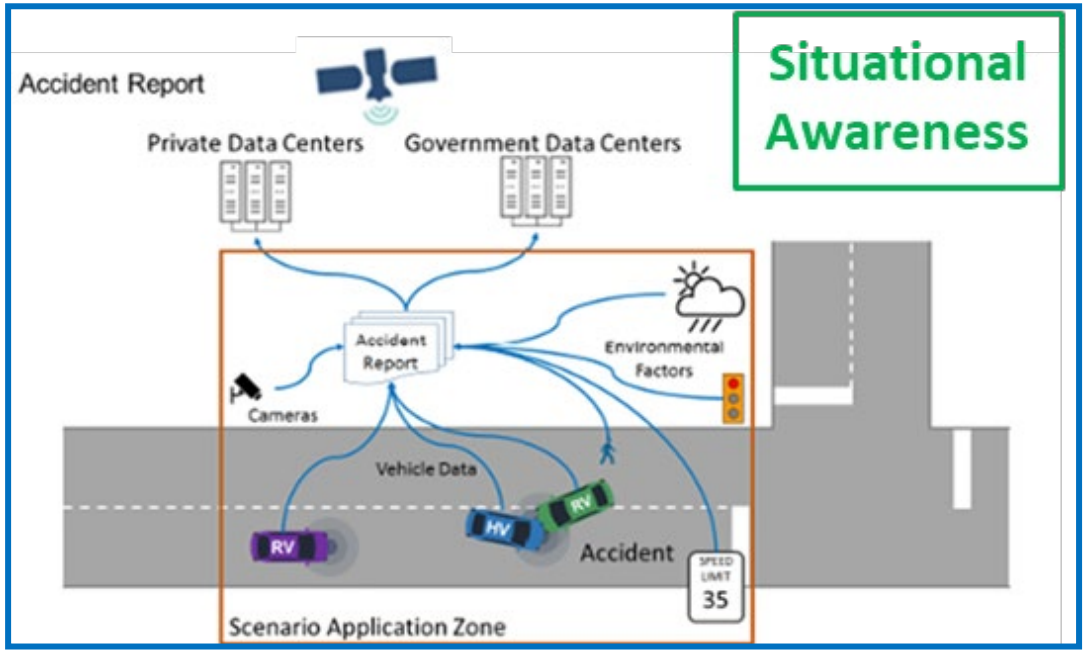
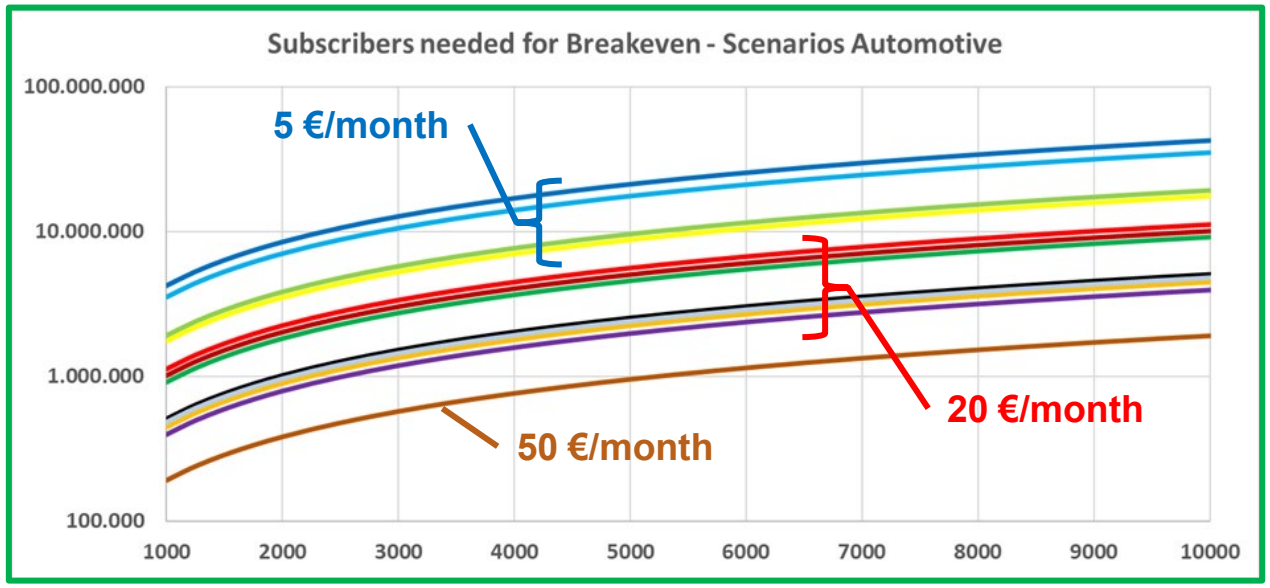
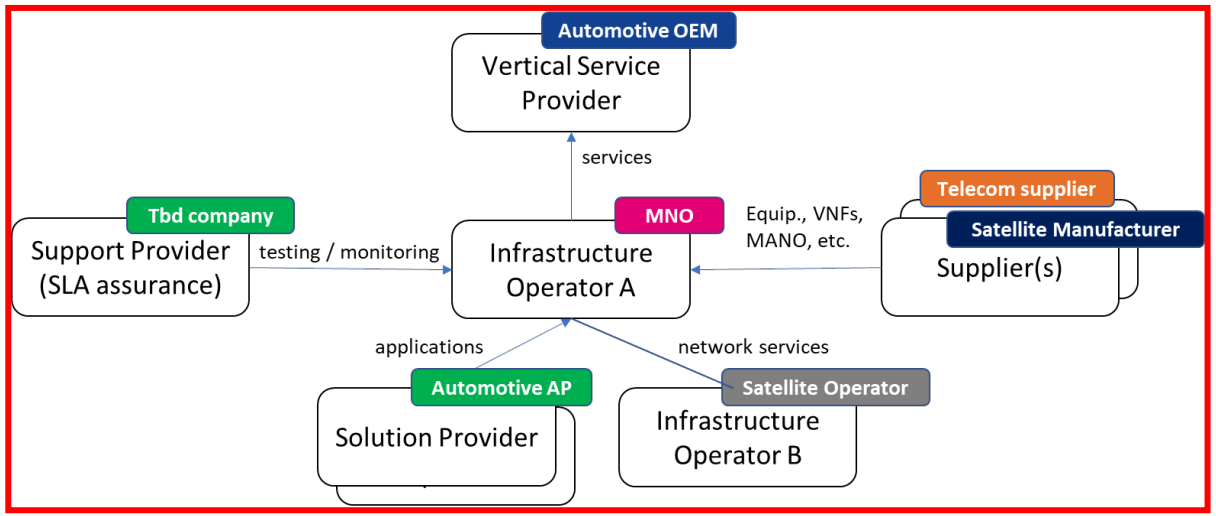
5G-IS Space Infrastructure

Major 5G-IS Results – 3

- **Compilation and characterization of promising automotive use cases accessible to non-terrestrial networks aligned with 5GAA**
- **Establishment of plausible service exploitation, value/supply chain and procurement models integrating all relevant stakeholders**
- **Demonstration of business viability through simplified cost amortization model with reasonable average revenue per user (5 €/mo – 20 €/mo) and number of subscribers (100 million new cars per year, more than 40 million in major automotive markets**







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5GEOSiS – 5G and Earth Observation Server in Space

Project Objectives

- **Explore concept of a 5G Repurposable Payload as a service**
- **Convergence of Space Functions combining Telecommunications and Earth Observation**
- **Identify and characterize use cases**
  - **Joint Processing and Communication (JPAC)**
  - **Integrated Sensing and Communication (ISAC)**
- **Develop/test breadboard of 5G software-defined payload providing its resources (computing, storage, and radio) as a service to Earth Observation missions.**
  - **Economy of scale and flexibility**
  - **Maintain suitable performance level**
- **Define technical baseline for prototype implementation**

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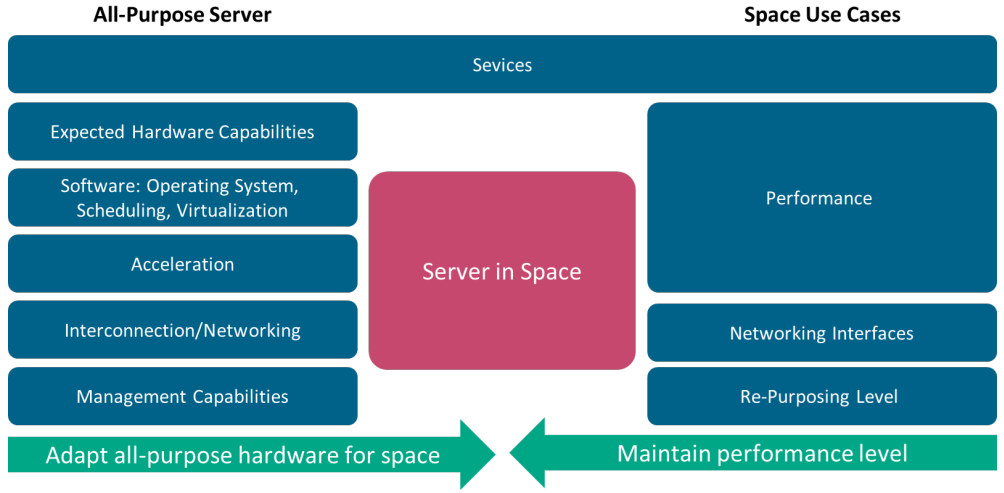
WP 1	WP 2	WP 3	WP 4	WP 7
Defined JPAC System Scenario(s)	Selected JPAC Technical Baseline & Specification	Design of JPAC Payload and Testbed	Testbed Planning, Implementation & Testing	Technology Assessment and Development Plan
WP 5	**WP 6**			
Defined ISAC System Scenario(s)	Selected ISAC Technical Baseline & Specification			



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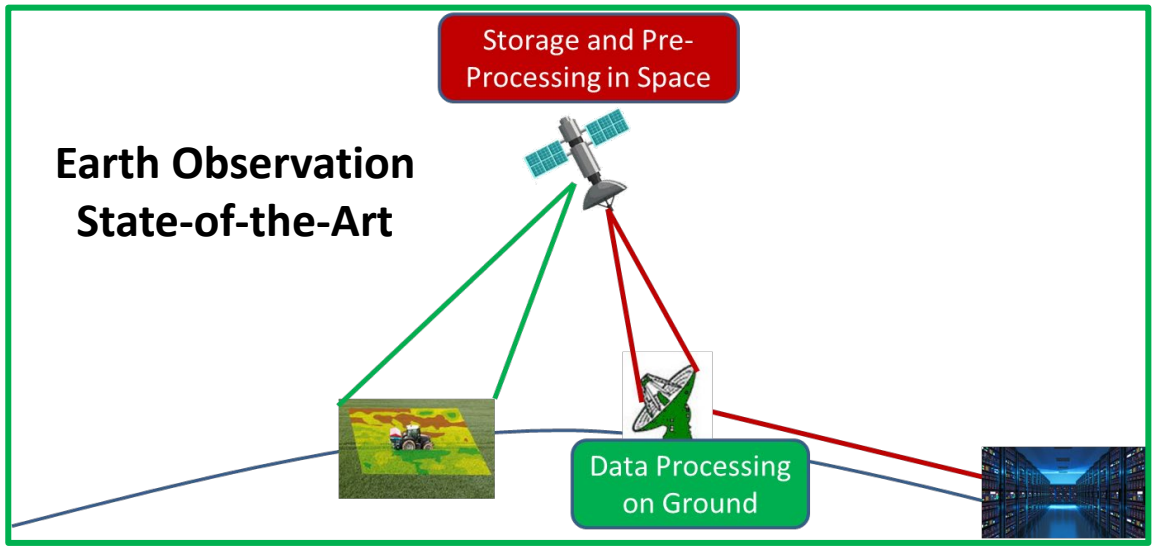
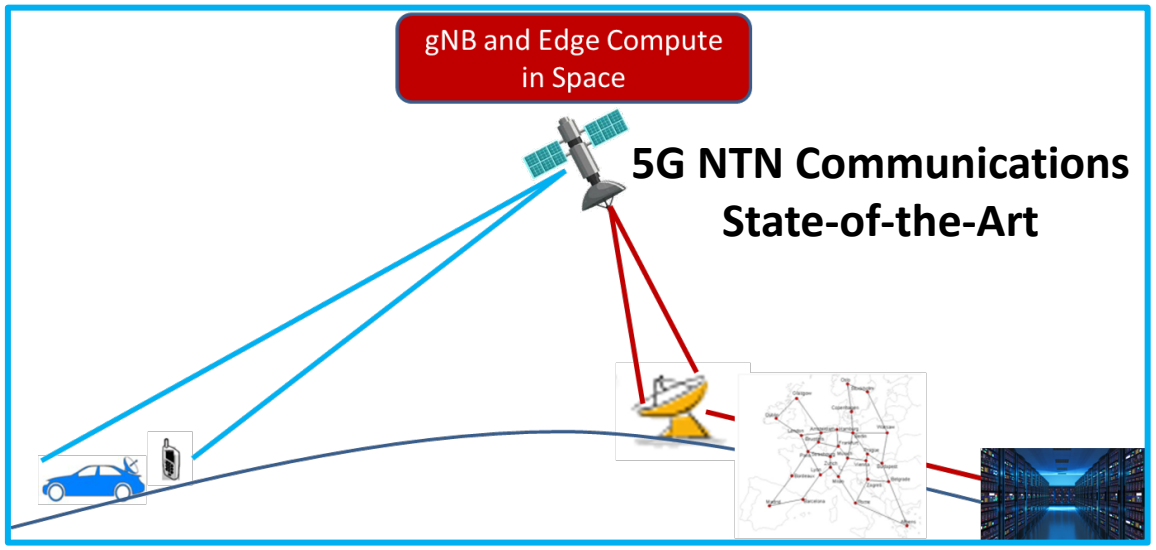
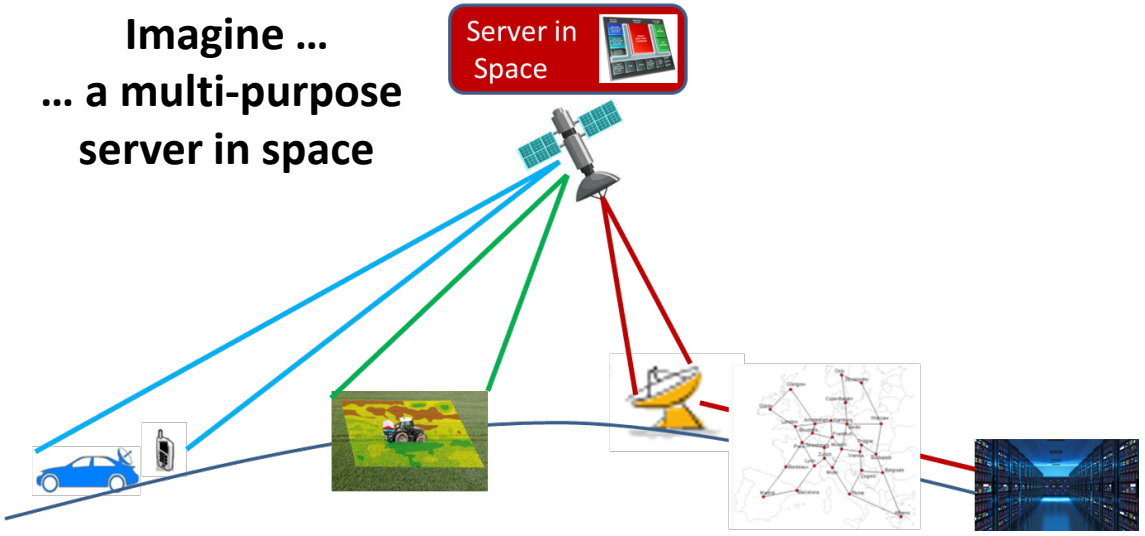
5GEOSiS – 5G and Earth Observation Server in Space



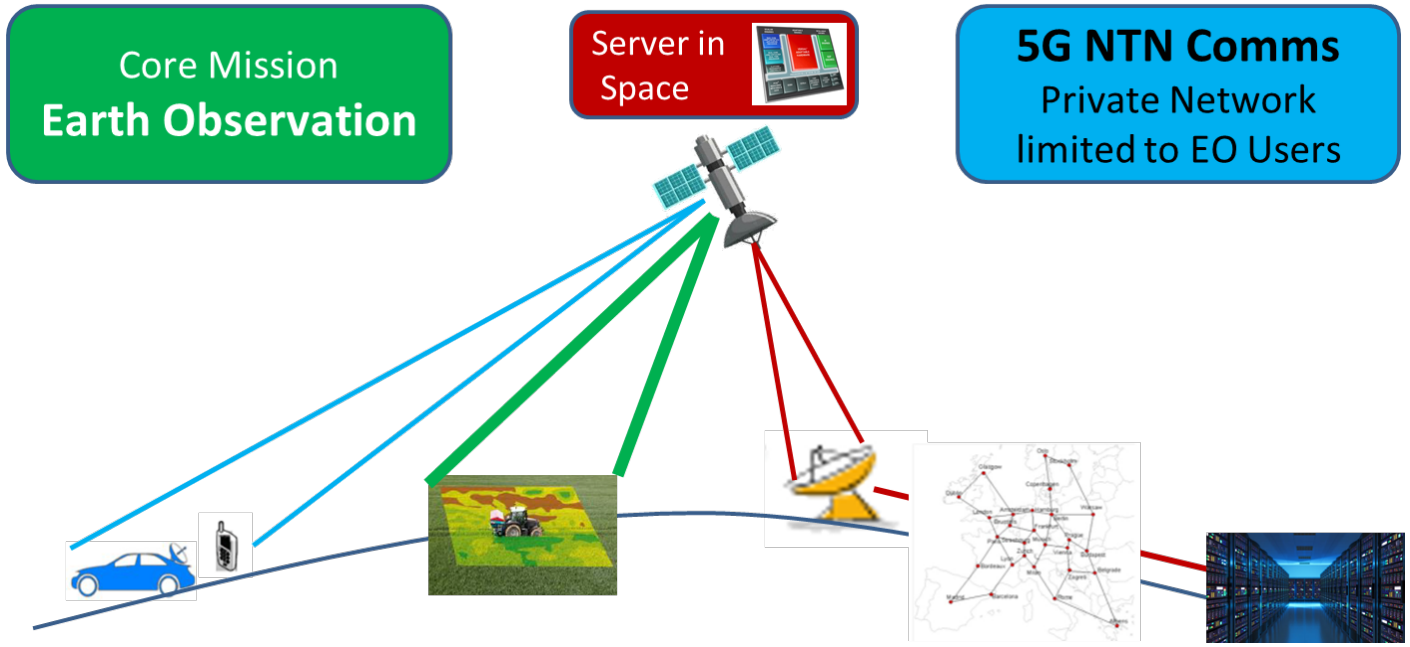


Imagine …
… a multi-purpose server in space



Cohabitation	Simplest form of convergence sharing of same platform and platform resources
Joint Processing and Communication	5G NTN Communication and Earth Observation payloads on-board the same satellite share all the data handling and processing elements as well as all platform resources
Joint Communication and Sensing	5G NTN Communication and Earth Observation functionalities on the same satellite share part or all of the RF chain → Integration (as far as possible) of sensing and communication functions

JPAC – Earth Observation uses 5G for Communications

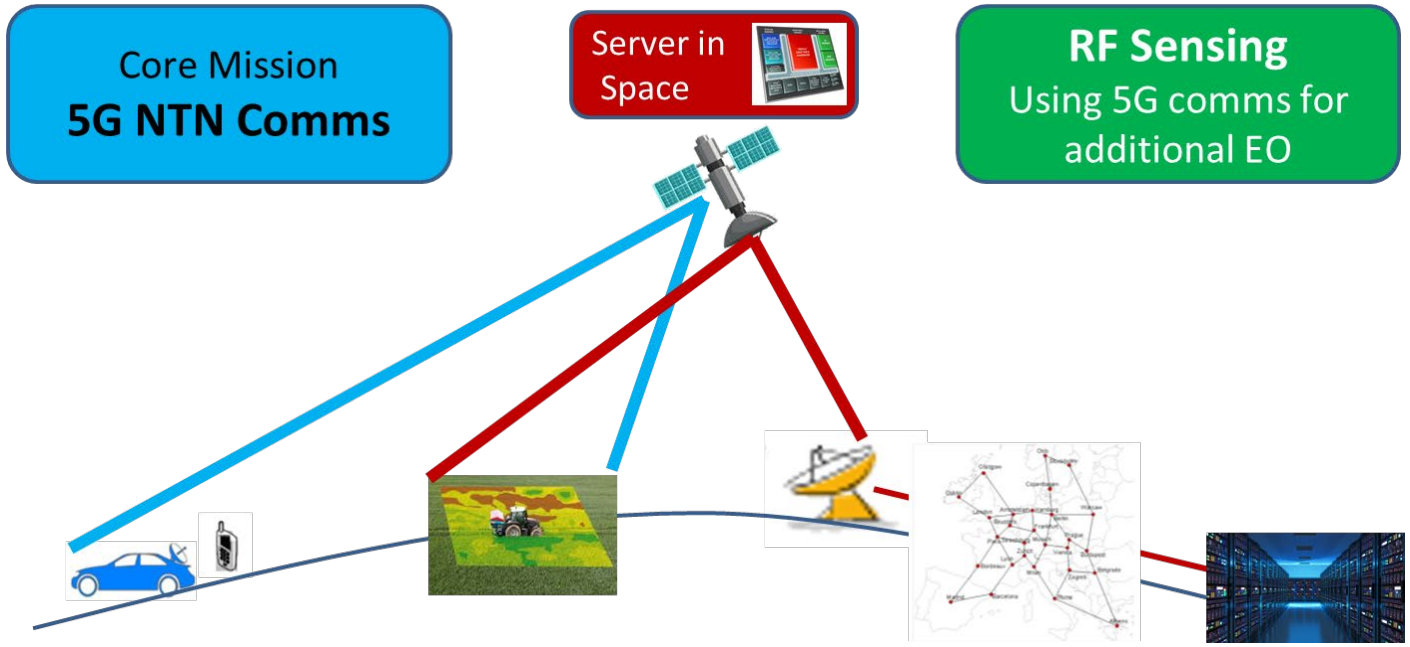


- Arbitrary EO payload – optical, hyperspectral, IR, Radar (real and synthetic aperture), RF
- Data handling via Server in Space

- Communication support for EO payload
- Additional 5G gNB with edge computing and network optimization for accredited users

- Reactive EO Commanding
- High data Rate low latency DownLink
- Full 5G Multi-acess Edge Computing
- Efficient Data Compression and Reduction
- Advanced On-Board EO data Processing
- Interactive Sensing & Communication Scenarios
- Network Management and Orchestration Optimization
- Everything/Anything as a Service

ISAC/JCAS uses 5G NTN for sensing



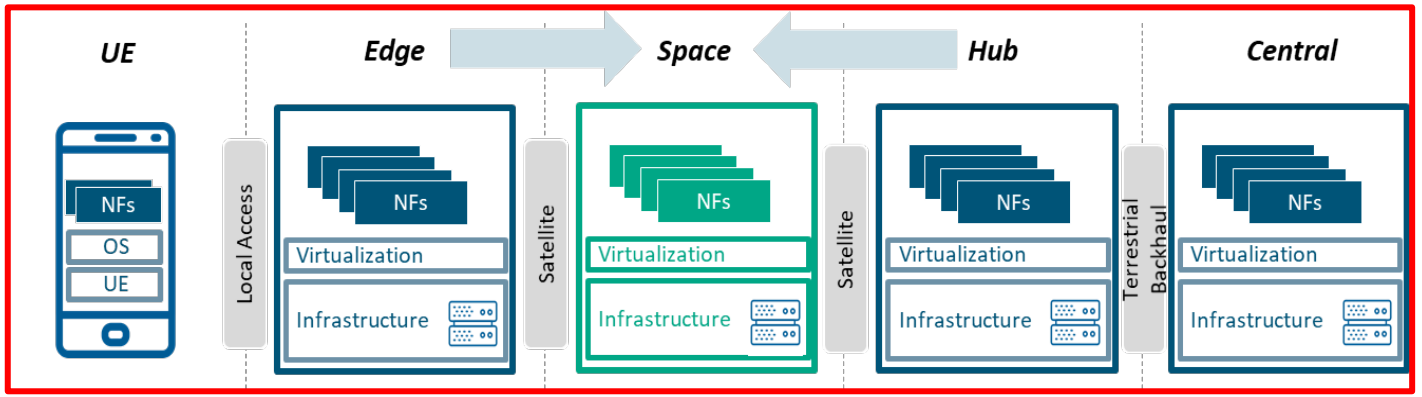
- Full 5G gNB functionality on board with
- User link &GW link
- Edge computing, Network optimization

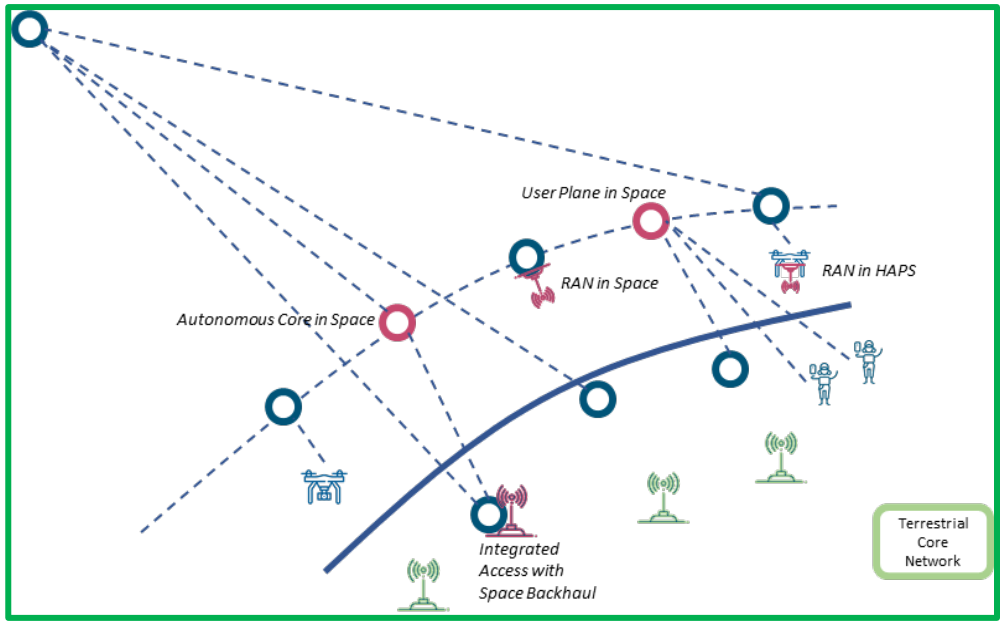
- Sensing Functionality
- (Pre-) Processing on Board
- Actionable Information

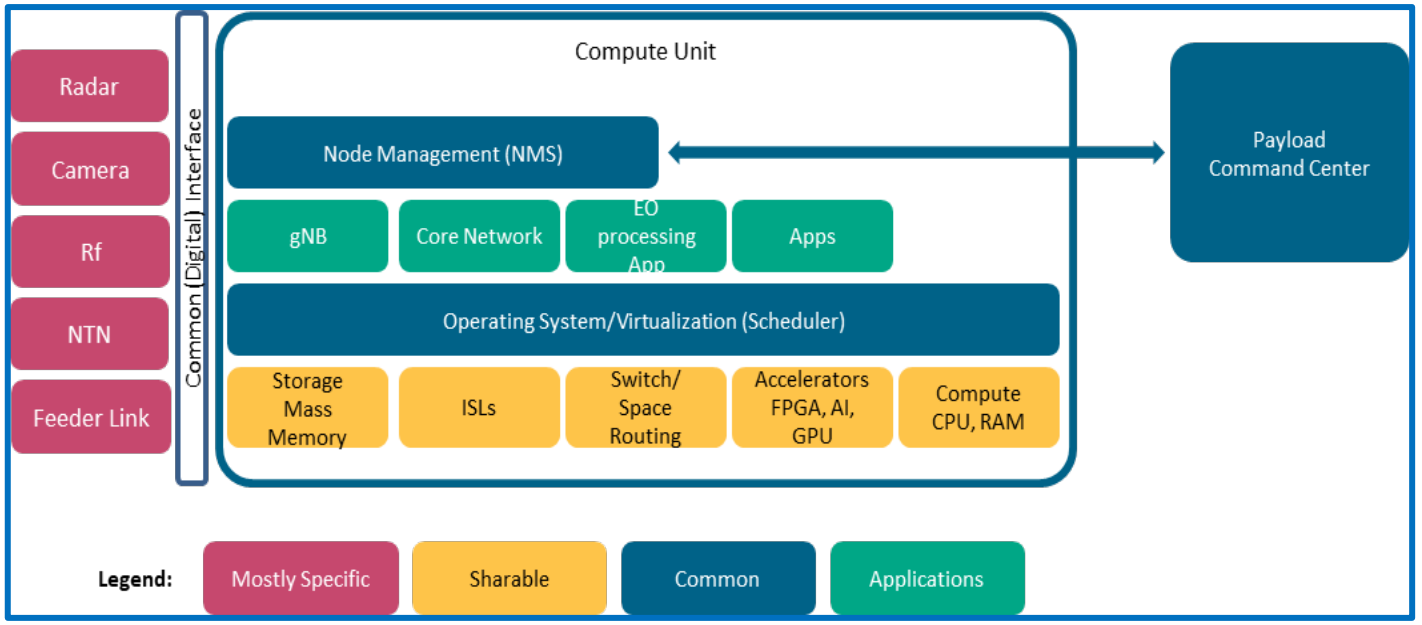
- Joint use of RF chain elements
- RF Channel Monitoring
- RF Spectrum Monitoring
- RF Interference Detection
- Passive bistatic radar (listener)
- Radar embedded into 5G
- 5G embedded into Radar
- Bistatic radar detection using 5G

Server in Space Concept

- **Placement of Network Functions in Space (from terrestrial edge and core)**
- **Development of a comprehensive Proof of Concept for the Server in Space**
- **Enabling 5G Networks in Space**







Summary and Impact

Main Takeaways

- 5G-IS Study validates VIABILITY and FEASIBILITY of 5G NTN space-based Infrastructures for complementing terrestrial networks to provide seamless E2E CONNECTIVITY SERVICES
- 5G NTN Satellite Connectivity for AUTOMOTIVE is jointly pursued by AUTOMOTIVE, MNOs, SPACE and Industry in 5GAA
- Cross-Industry CO-Operation, -Innovation & CO-Creation is KEY
- INTELLIGENT SATELLITE PAYLOADS are the FUTURE to fully realize NTN capabilities

Standardization Activities and Way Forward

- Project partners (Fraunhofer, Airbus) are very active in standardization –
  - Standardization bodies – 3GPP, ETSI, …
  - Special Standardization Interest Group
  - Working within 5GAA
- Regenerative Payloads – topic of 3GPP Rel. 19 are key for Server in Space.
  - 5G gNB on-board satellite
  - Edge computing functionalities
  - Additional network functions
- Further standardization needs towards 6G
  - Advanced gNB split options and intra-gNB interfaces
  - Edge computing and advanced processing
  - Integrated sensing and communication – also from Space !!
  - … further input may come from 5GEOSiS