Hexa-X-II Workshop on 6G architecture and standardization

Hexa-X-II E2E system

Hexa-X-II

hexa-x-ii.eu

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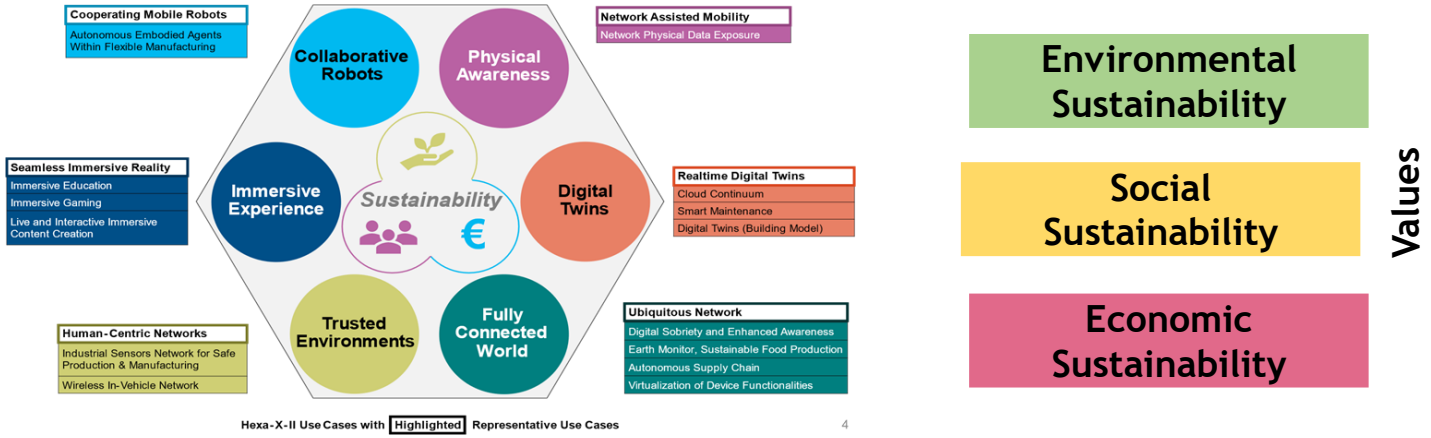
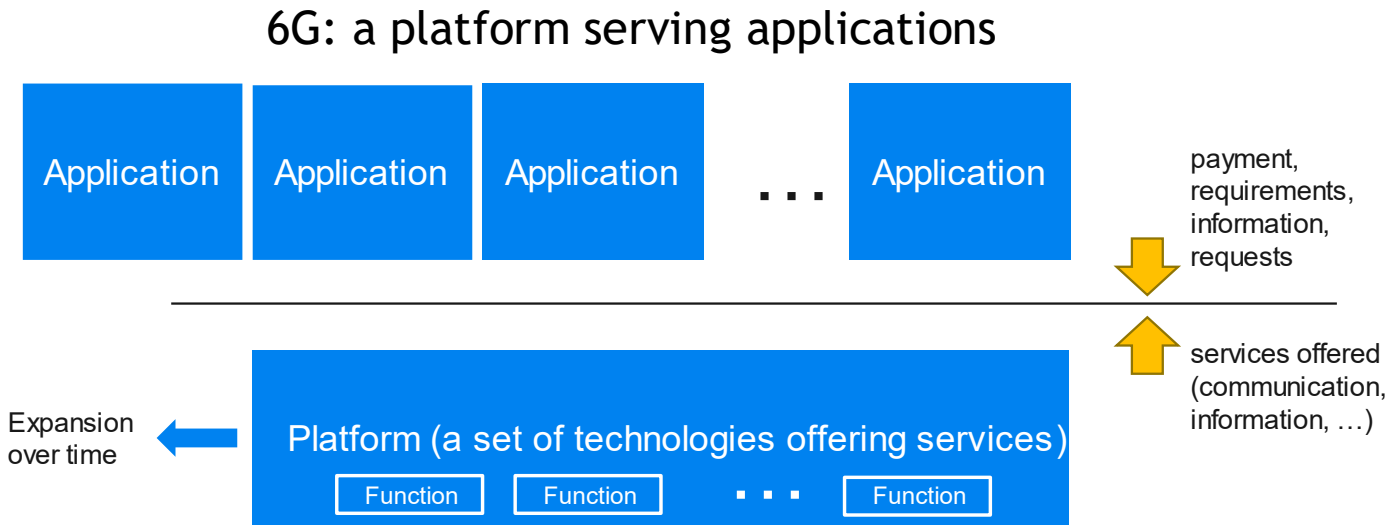
6G: A platform serving applications and enabling values

- A platform for a wide range of technologies towards a wide range of applications, users, verticals, and ecosystem
- Designed to enable values to the environment, society and economy
- The networks should expose data through simple APIs and allow for interaction with applications

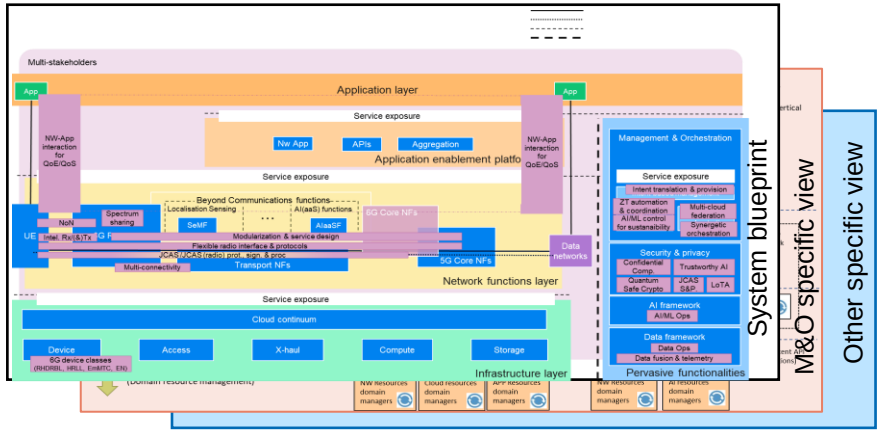


Source Hexa-X-II D1.2

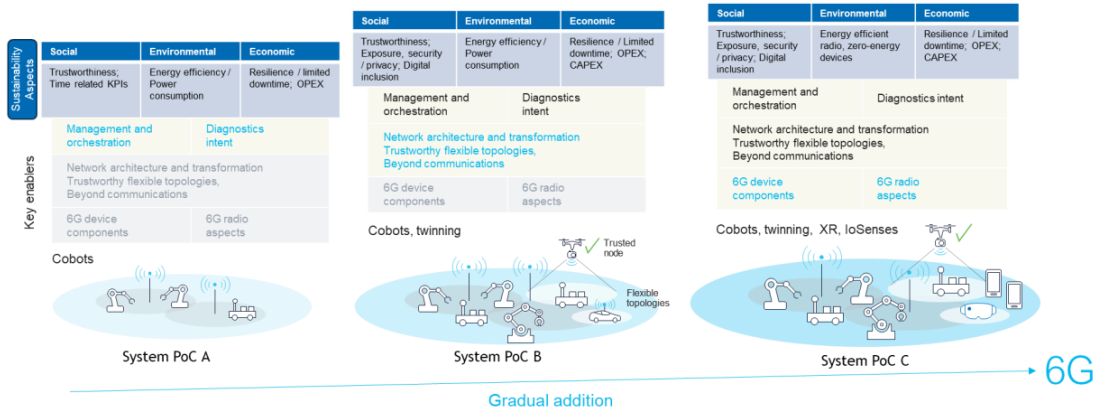


Hexa-X-II E2E system design

Top-down approach
Design principle
Evolution towards 6G
System requirements
System blueprint



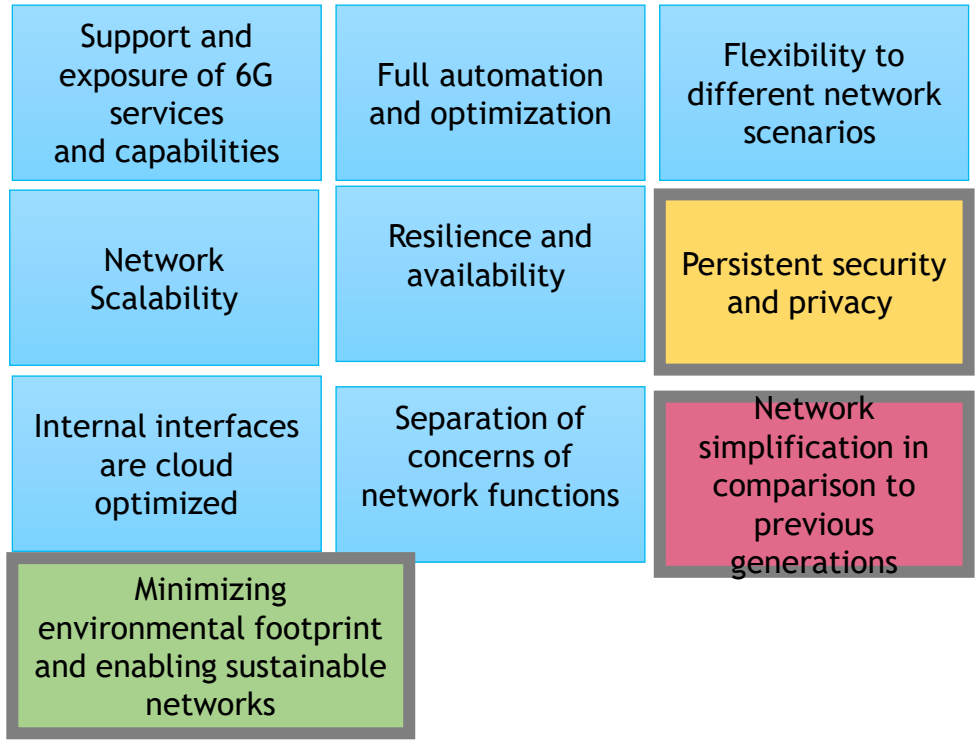
Holistic E2E system and specific views
Selection of enablers
System-PoC for Validation



Bottom-up approach
Architecture enablers
Radio protocols
Intent-based M&O
Security, privacy and resilience, …

Design principles & requirement for 6G End-to-End System

Ten 6G design principles achieving the 6G key values realization of environmental, social, and economic sustainability.



- Crystallized around simplification, security/privacy, and sustainability

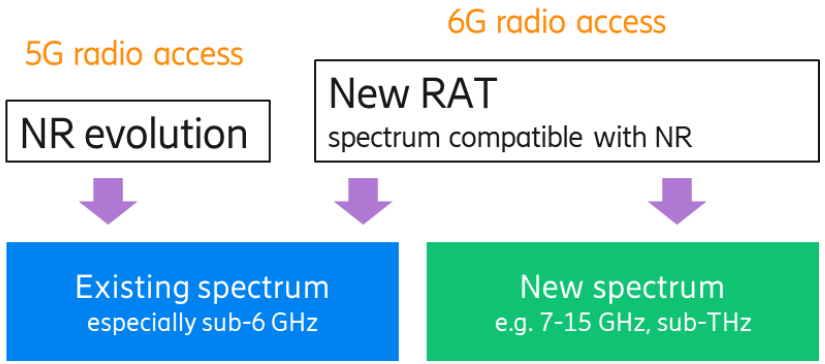
Source: [HEX223-D21]

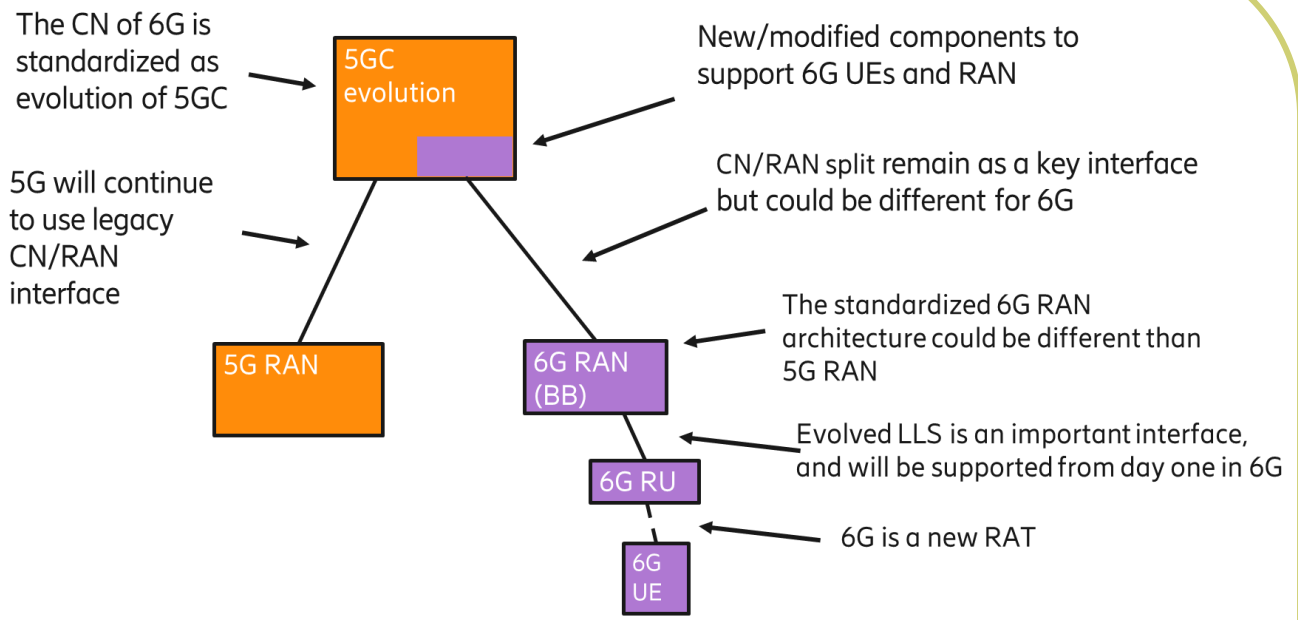
Technical requirements grouping per use cases	
• **Seamless Immersive Reality** bitrates <250 Mbps both uplink and downlink guaranteed E2E latency<10 ms accurate positioning of the devices. • **Cooperating mobile robots** bitrates <10 Mbps E2E latencies <0.8 ms high service reliability (5-7 nines) and similar positioning accuracy. • **Network assisted mobility** bitrates <10 Mbps guaranteed E2E latencies <20 ms guaranteed coverage >99.9% service availability 99.99% within the service space, working at high speeds and supporting seamless handovers.	• **Real-time digital twin** bitrates >100 Mbps guaranteed E2E latency ~1 ms very high service reliability (7 nines) and coverage (4 nines) high local connection densities (<10 /m^2 indoor). • **Ubiquitous Network** service area to >99% of Earth's surface, Bitrate <25 Mbps E2E latency 10-100 ms • **Human-centric services** sets extreme requirements on the security, privacy, and reliability (up to 99.999%), while requiring modest latencies (100s ms).
• **Transmission jitter/packet delay variations** ranges from 100 µs to 100 ms for prospective use cases from other SNS JU projects	

A complete description of Hexa-X-II system requirements (technical & functional) is available in Hexa-X-II D2.3

Evolution towards 6G

A 6G RAT should support an extended spectrum range than 5G, provide open interfaces, and plug into an updated 5G CN



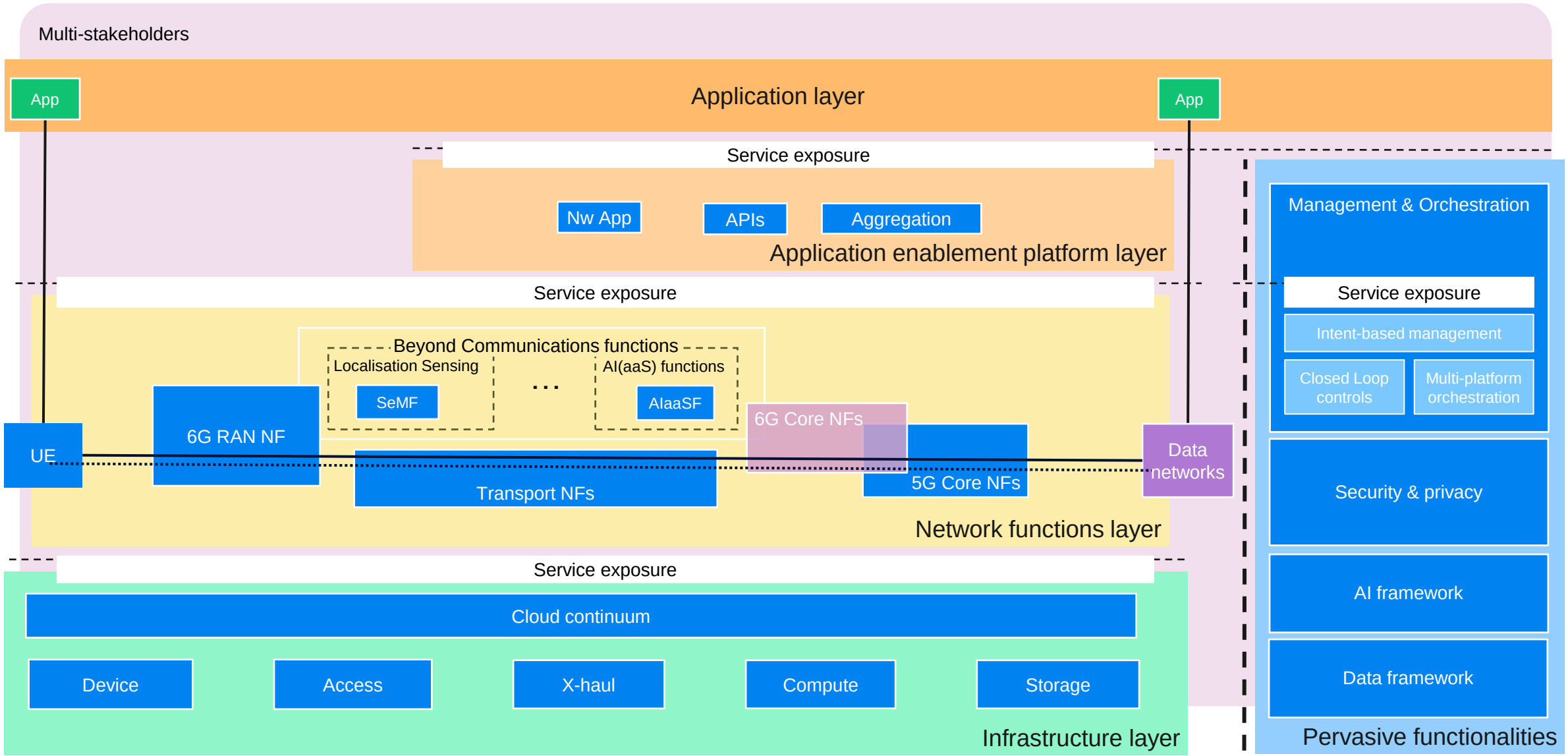


LLS = Lower layer split

Principle 9
Simplification

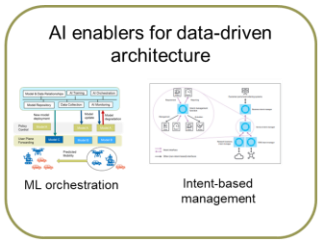
Source: [HEX223-D21]

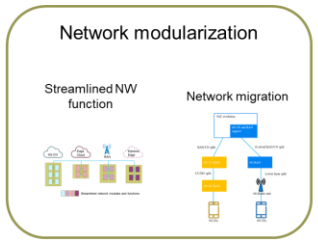
Overall (interim) system blueprint

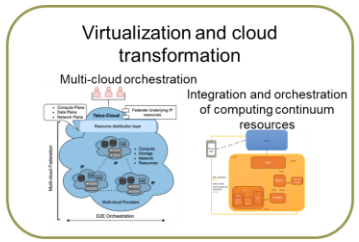


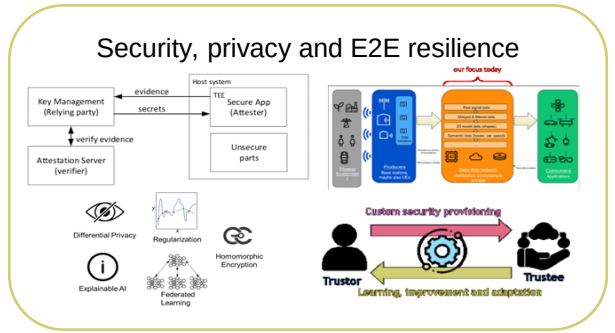
Source: [HEX224-D23]

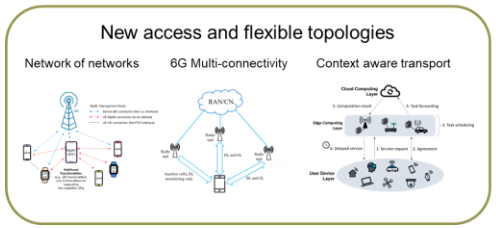
From 6G enablers to 6G system design?

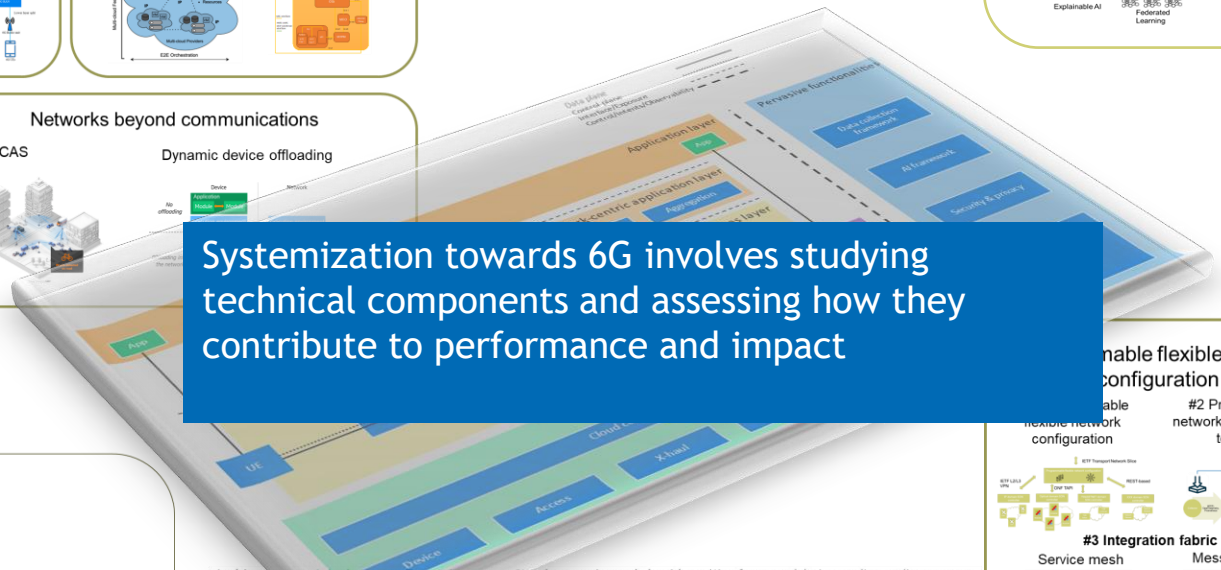




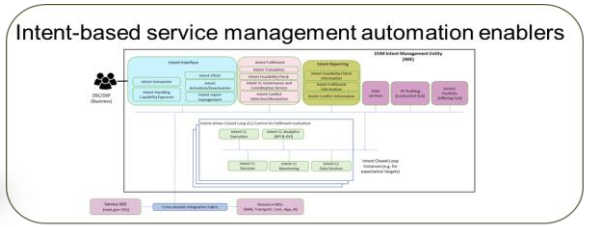


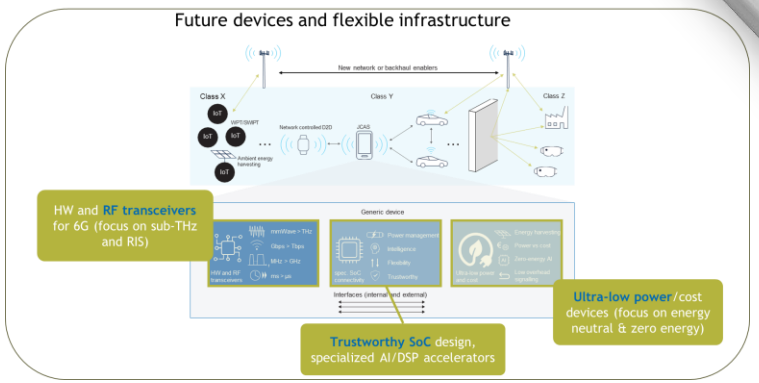


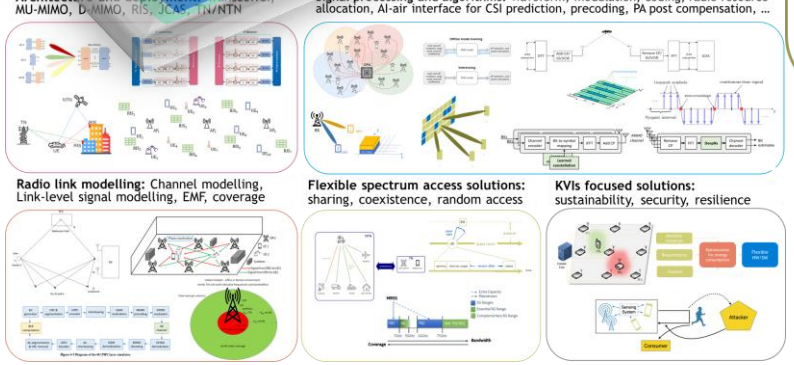


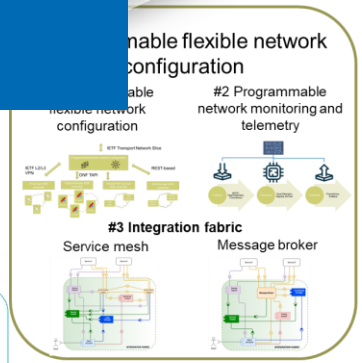


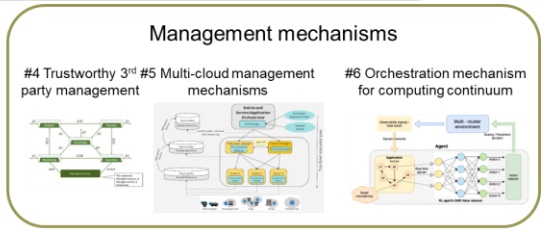
Systemization towards 6G involves studying technical components and assessing how they contribute to performance and impact

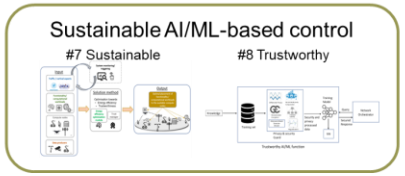


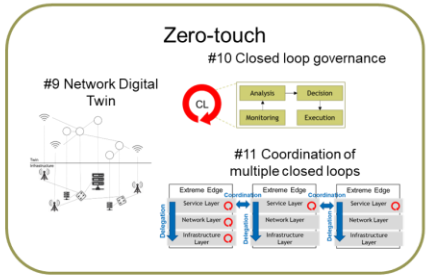








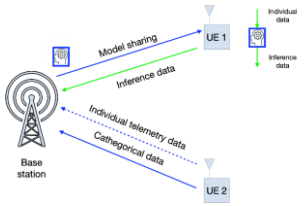




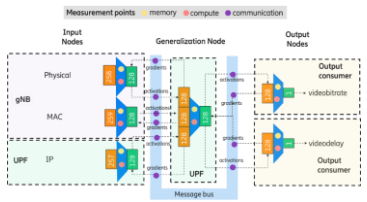
Architectural enablers

AI enablers for data-driven architecture

Data and model sharing

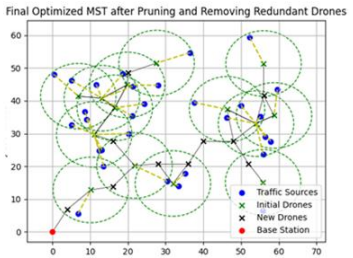


Split learning setting

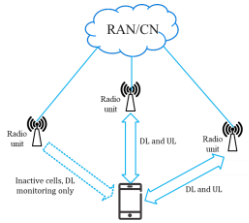


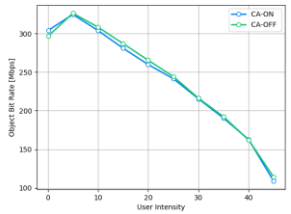
New access and flexible topologies

Flexible topology with optimal drone placement

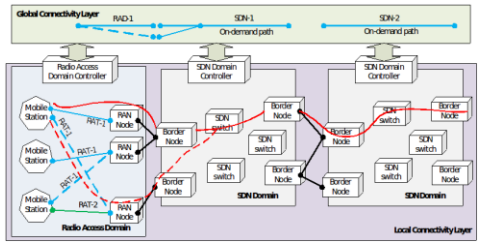


Multi-connectivity



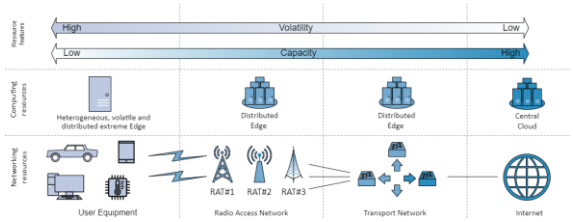


Context aware management



Virtualization and cloud transformation

Orchestration in the compute continuum

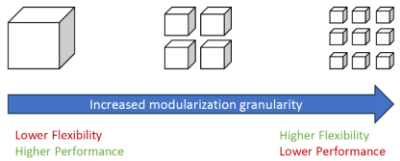


Principle 9
Simplification

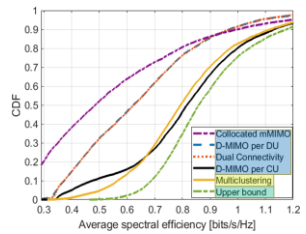
Principle 10
(Env.) **sustainability**

Network modularization

Modularization granularity

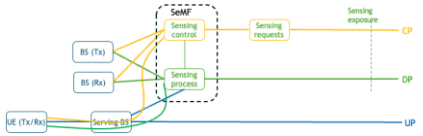


Modular network functions for cell-free MIMO

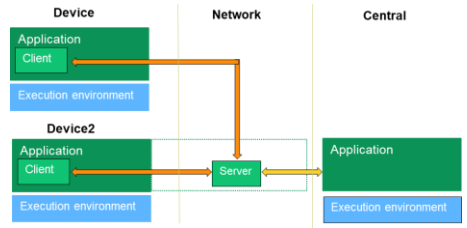


Networks beyond communications

JCAS



Dynamic device offloading



Principle 3
Flexibility

Source: Hexa-X-II D3.3 – Initial analysis of architectural enablers and framework

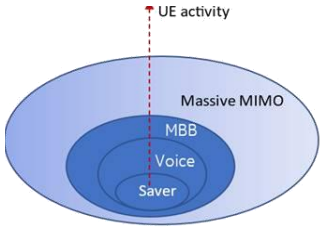
Radio interface and protocol enablers

Control plane

Flatter RRC

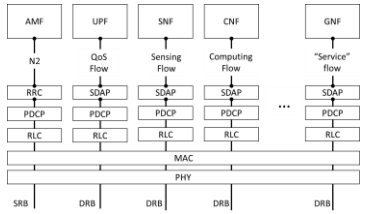
- Avoiding hierarchy levels
- ASN.1 shall not enforce nor prohibit procedures

Modular RRC

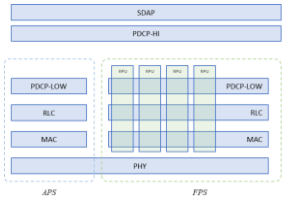


User plane

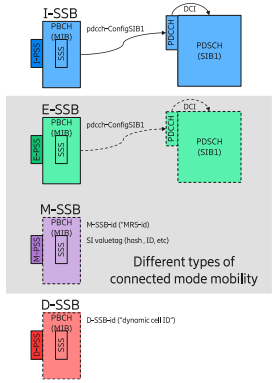
UP for Beyond Communication



Two-stacks UP
High/low bitrate stack

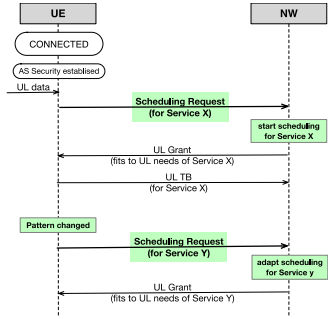


Separation of IDLE/CONNECTED SSB



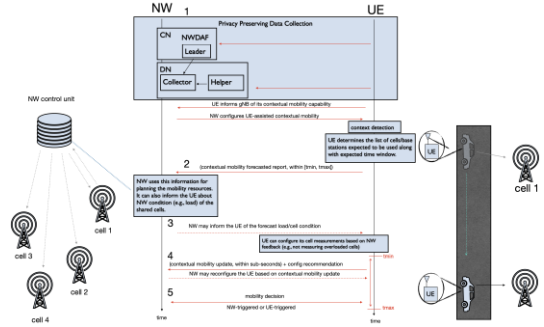
Reduce signalling overhead

Application-NW interaction for service differentiation

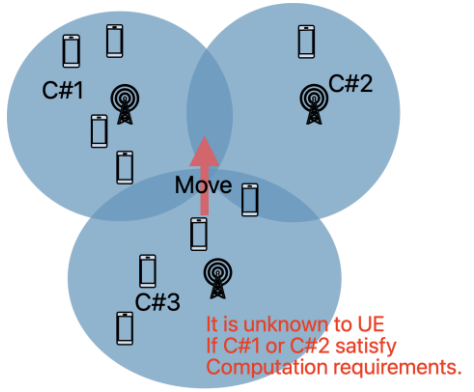


Mobility improvements

Data-driven mobility



Computational aware mobility



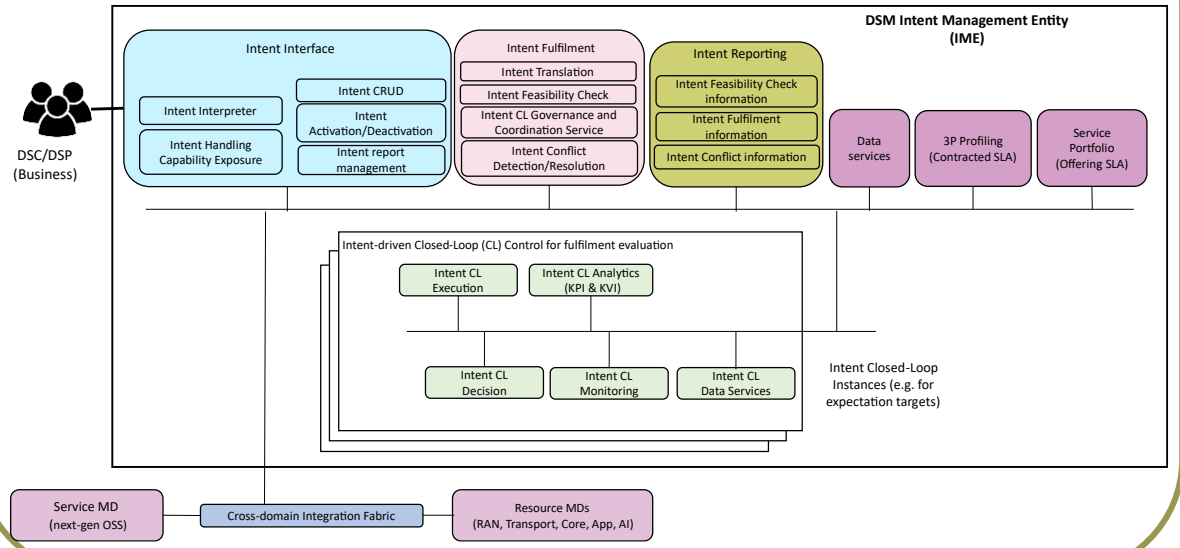
Principle 9
Simplification

Principle 10
Sustainability

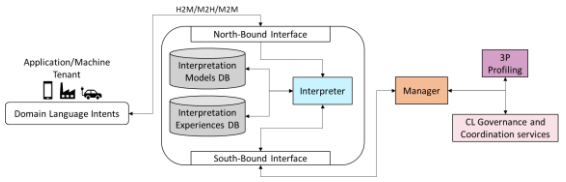
Source: [HEX224-D23]

Management & orchestration enablers

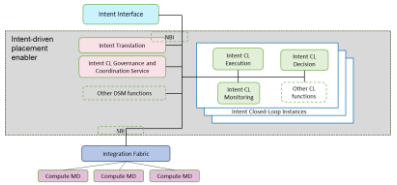
Intent-based management



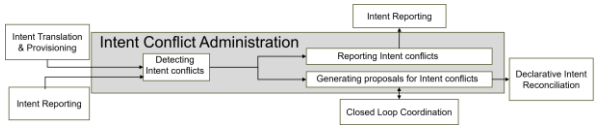
Human-machine intent interface



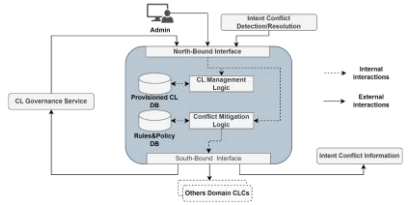
Intent-based placement



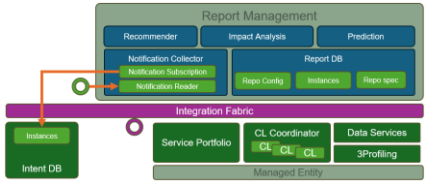
Intent conflict administration



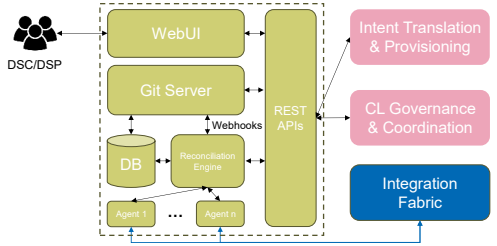
Intent closed-loop coordination



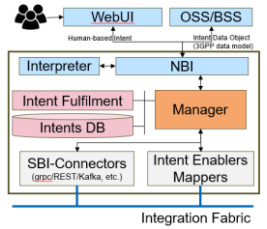
Intent Reporting



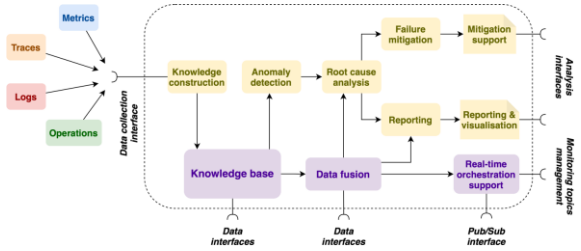
Declarative Intent Reconciliation



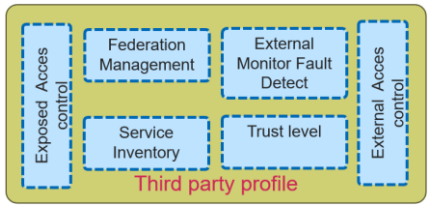
Intent translation and provisioning



Data fusion mechanism based on telemetry data



3rd Party Services



Principle 9
Simplification

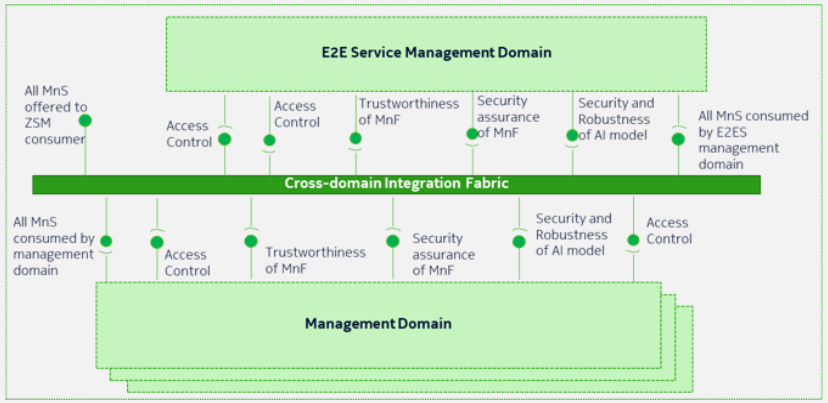
Principle 2
Full automation

Source: [HEX224-D23]

Security privacy and resilience (SPR) enablers

SPR controls concept and interfaces

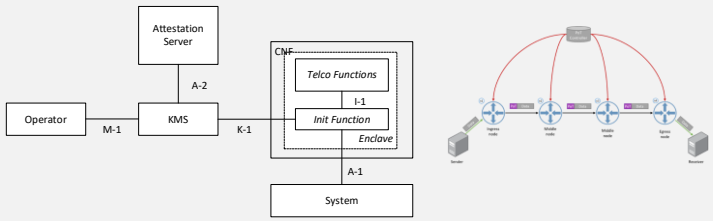
- Use a general loosely coupled model, compatible with the OAM integration fabric
- Use ETSI ZSM014 as foundation for these interfaces



Principle 6 **security and privacy**

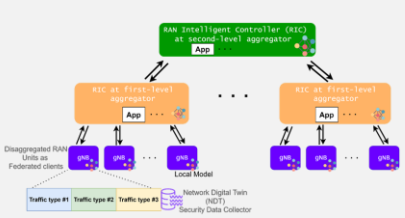
Principle 5 **Resilience and availability**

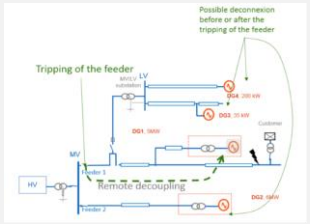
SPR control at deployment TRLs



Confidential network
Distributed ledgers for decentralization/multi-stakeholders

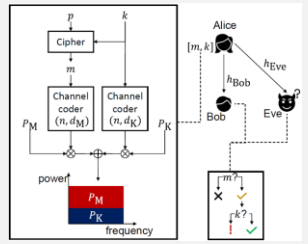
SPR controls at validation TRLs

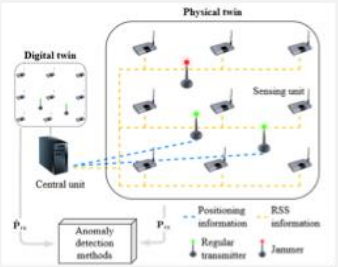




Trustworthy AI (framework for security and privacy in federated learning, Explainable AI against adversarial attacks on IDS
Quantum resistant crypto
E2E resilience simulation

SPR controls at basic TRLs





Physical layer security

- Context awareness
- DT- and ML-enabled anomaly detection
- JCAS threat mitigation
- Physical layer deception

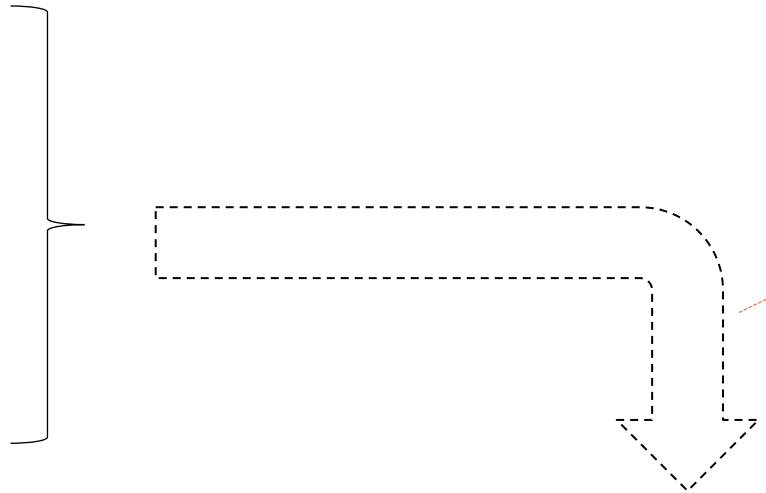
Source: [HEX224-D23]

IDS: Intrusion Detection System

Enablers from other SNS-JU projects

Hexa-X-II Enablers

Other Enablers
- *From other SNS projects*



Analysis of other SNS stream B enablers

- Identify Missing/undercovered enablers in Hexa-X-II - but important for the 6G platform
- Align and possibly complete Hexa-X-II design principles
- Evaluate other Stream B project (sub) system architecture to align and possibly complete Hexa-X-II system architecture

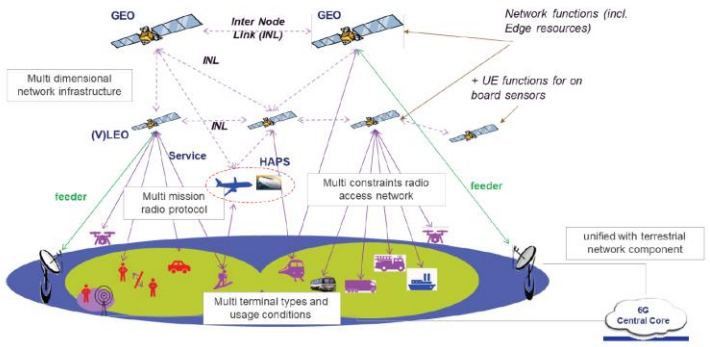
6G blueprint design
- E2E system blueprint – overall
- Specific views

System design guidelines
- Migration from 5G to 6G
- System design principles
- 6G system requirements

Enablers from other SNS-JU projects

Complement Hexa-X-II enabler
New enabler

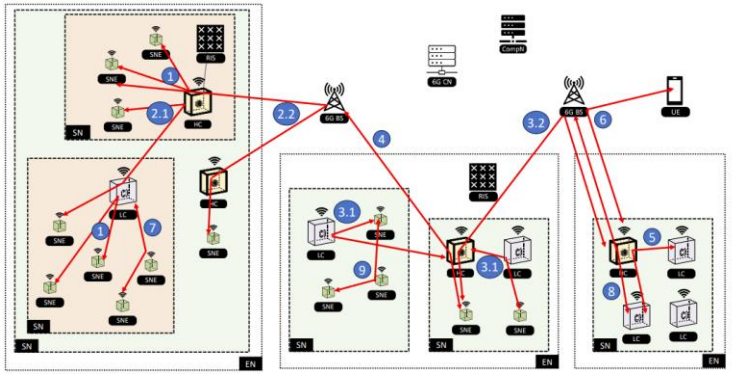
6G-NTN



- Regenerative payload on NTN

* 6G-NTN, deliverable D3.5 ”Report on 3D multi layered NTN architecture,” March 2024

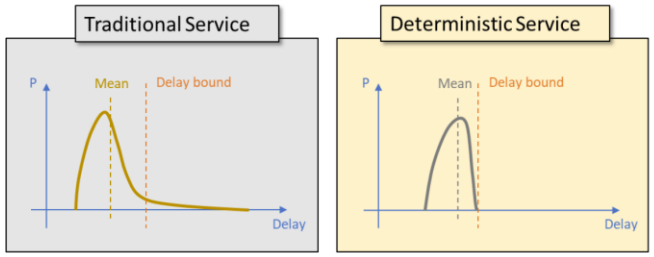
6G-SHINE



- In-X subnetwork - Reference architecture for indirect communication mode

*6G-SHINE deliverable D2.2 ” Refined definition of scenarios, use cases and service requirements for in- X subnetworks,” February 2024

Deterministic-6G



- Time sensitive network
- Wireless-friendly, adaptive end-to-end scheduling algorithms

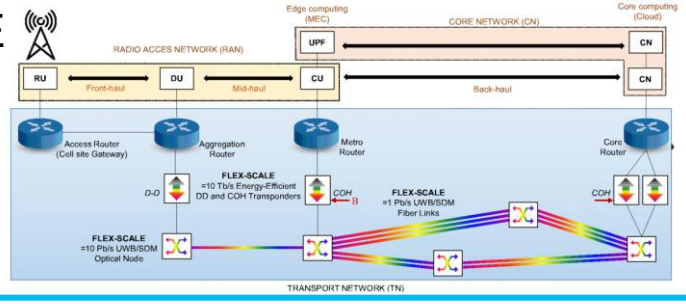
* DETERMINISTIC6G, deliverable D3.1 ” Report on 6G convergence enablers towards deterministic communication standards,” December 2023

PREDICT-6G

- cross-domain determinism, multi-domain dataplane

* PREDICT-6G deliverable D2.1” Release 1 of PREDICT-6G MDP innovations”, August 2023

FLEX SCALE



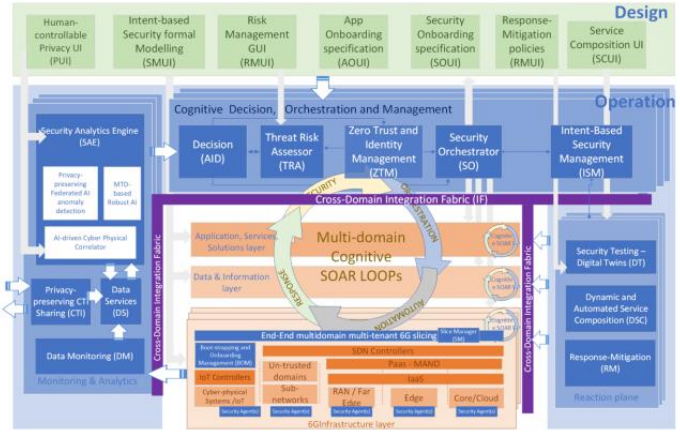
- high speed and energy-efficient transport network with programmable transceivers

*FLEX SCALE deliverable D2.1 6G “Network Requirements”, April 2023

Enablers from other SNS-JU projects

Complement Hexa-X-II enabler
New enabler

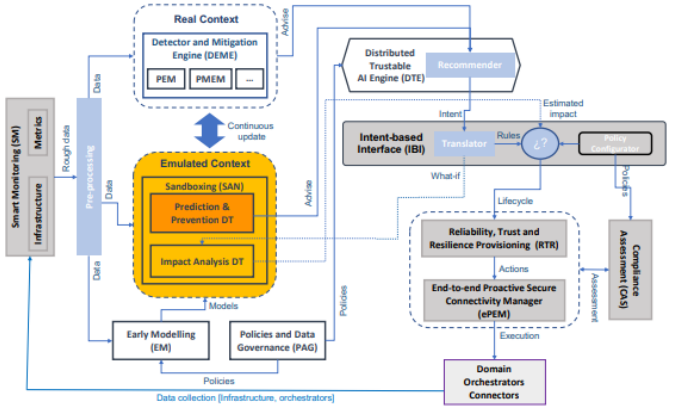
RIGOUROUS



- DevSecOps framework cross domains

*RIGOUROUS deliverable D3.1. Design plan of the multi-domain automated security orchestration, trust-management, and deployment

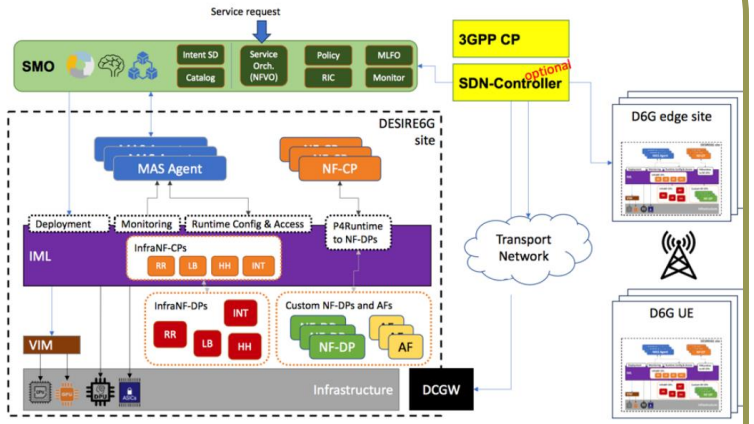
HORSE



- NDTs (prediction&prevention, what-if scenario)

* HORSE deliverable D2.2 HORSE Architectural Design (IT-1), September 2023

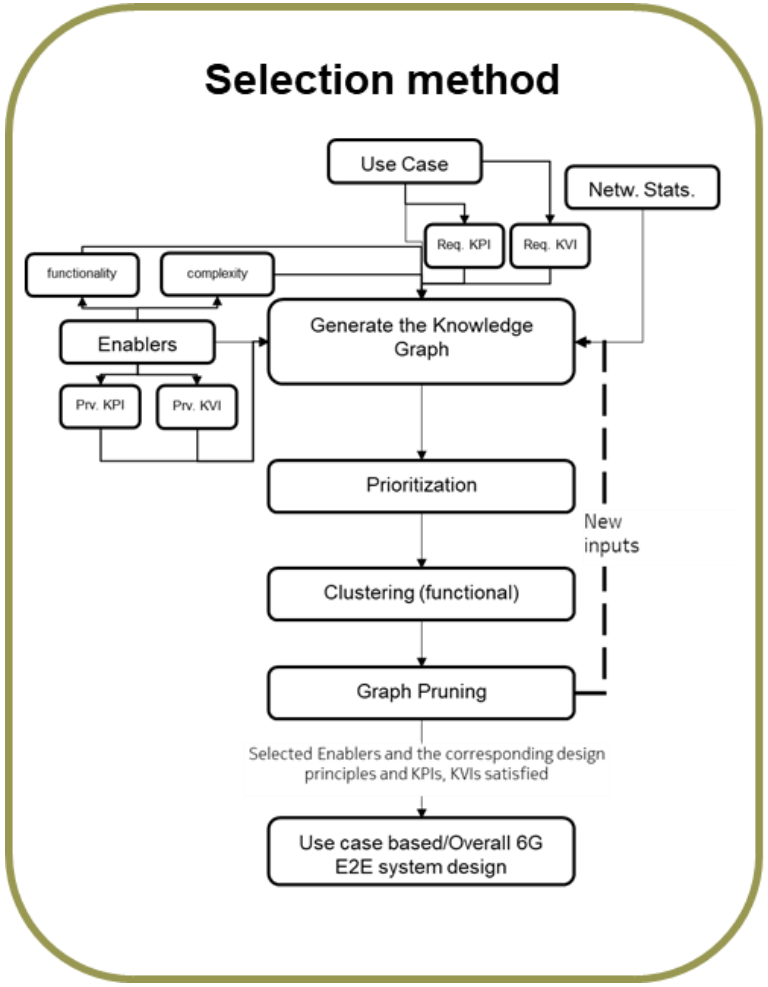
DESIRE-6G

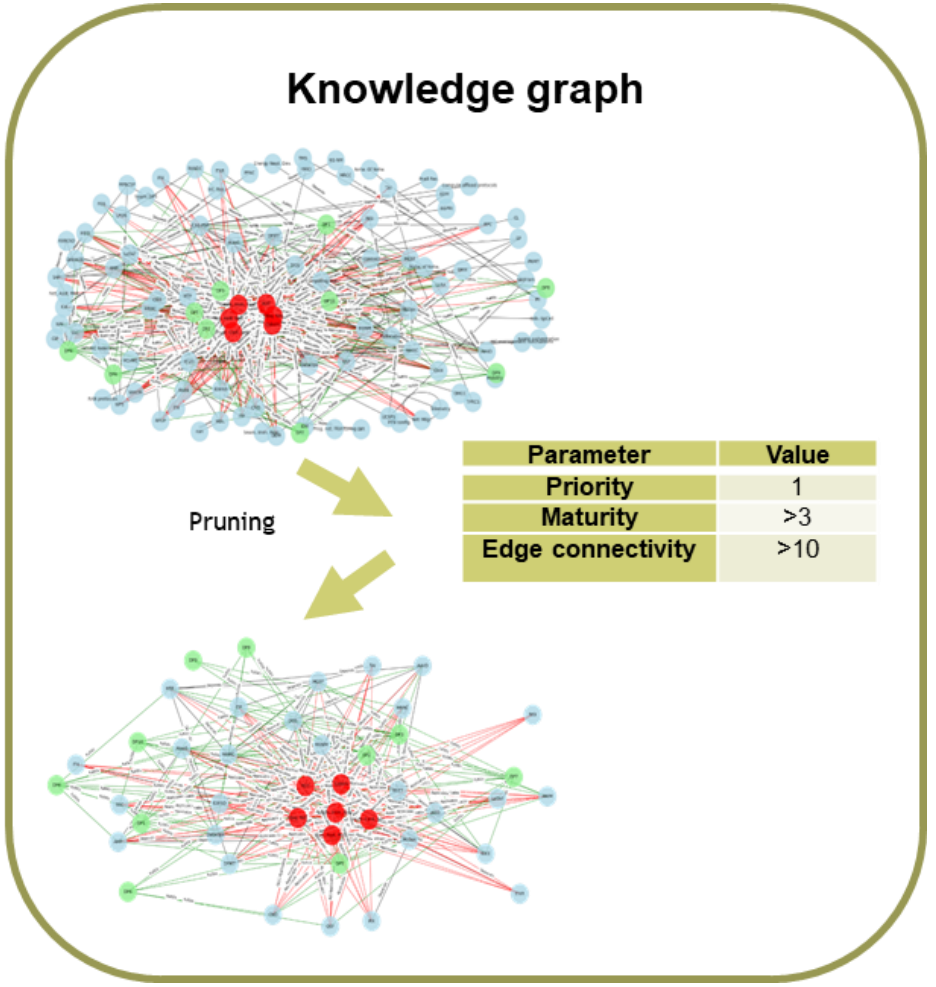


- Intent-based orchestration and LC management, distributed agent-based system

* DESIRE-6G deliverable D3.1: Initial report on intelligent and secure management, orchestration, and control platform, November 2023

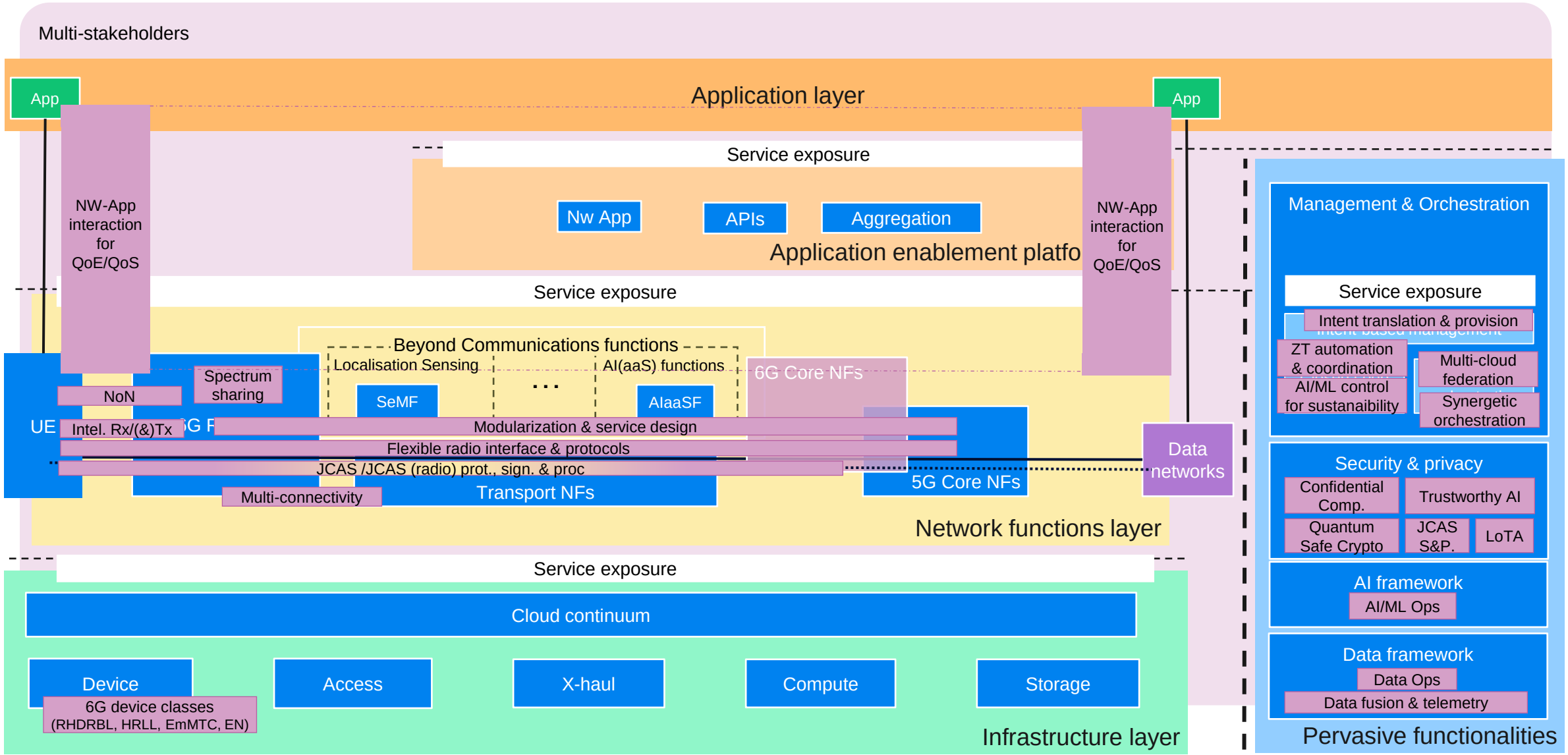
Enabler selection process





Source: [HEX224-D23]

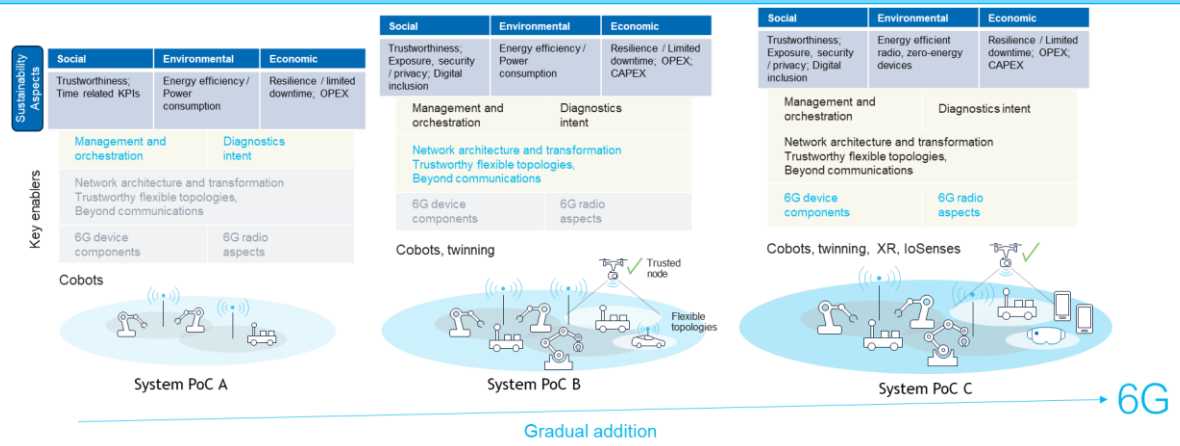
Mapping selected enablers in the 6G E2E system blueprint



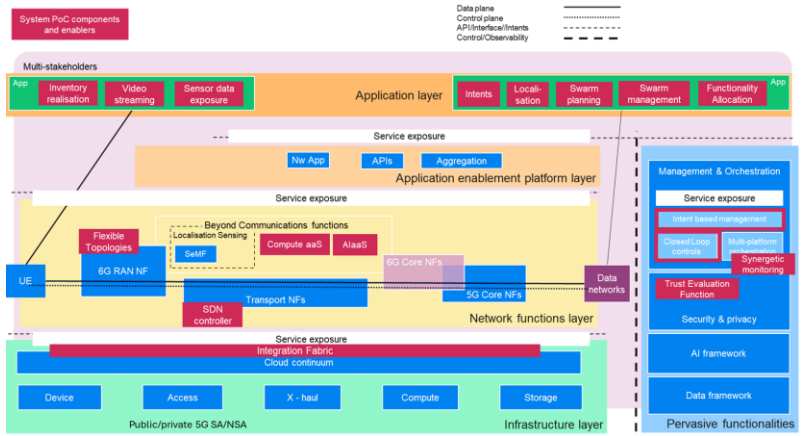
Source: [HEX224-D23]

System Proof of Concept

System PoC, with gradual addition to demonstrate system's ability to meet the stringent KPIs and KVIs essential for 6G networks.

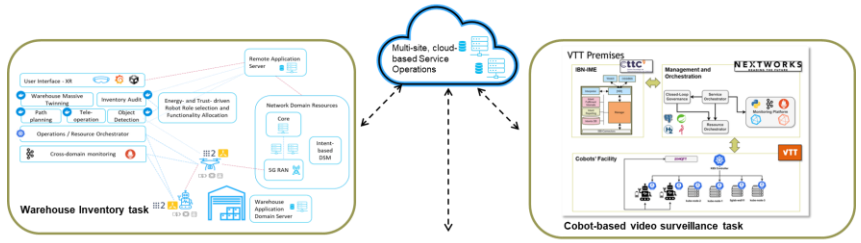


System-PoC functional and performance aspects in the system blueprint

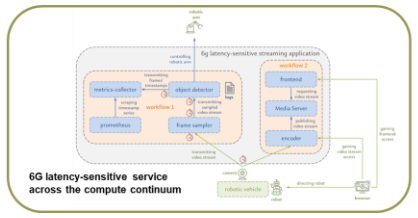


Component/enablers
Application components, SDN for transport, compute offload, AI as a service, intent-based networks, flexible network topologies, closed-loop automation, and AI-based scenarios, service integration fabric across device and cloud

Implementation with **multi-sites and device-cloud continuum environment for cobot-based latency sensitive services scenarios**



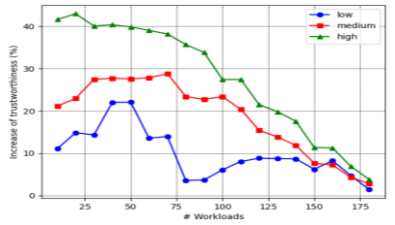
Energy- and trust-driven management & orchestration
Flexible topologies
Training and inference of collaborative distributed machine learning model

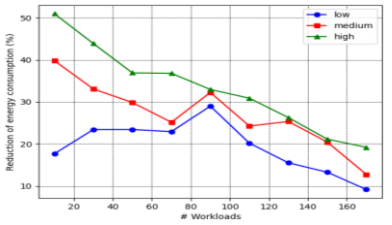


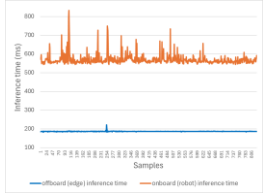
Intent Translation and Provisioning
Synergetic monitoring
Real-time Zero-touch control loops automation and coordination system
AI based autoscaling & migration of real-time sensitive services

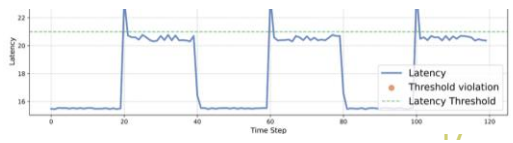
Validation results

- **Meet the key system design principles:** simplification, automation, scalability, resilience, and security.
- **KPIs & key values:** low latency for demanding services, zero-downtime, energy-efficient, trust-driven operations, and reduced operational costs

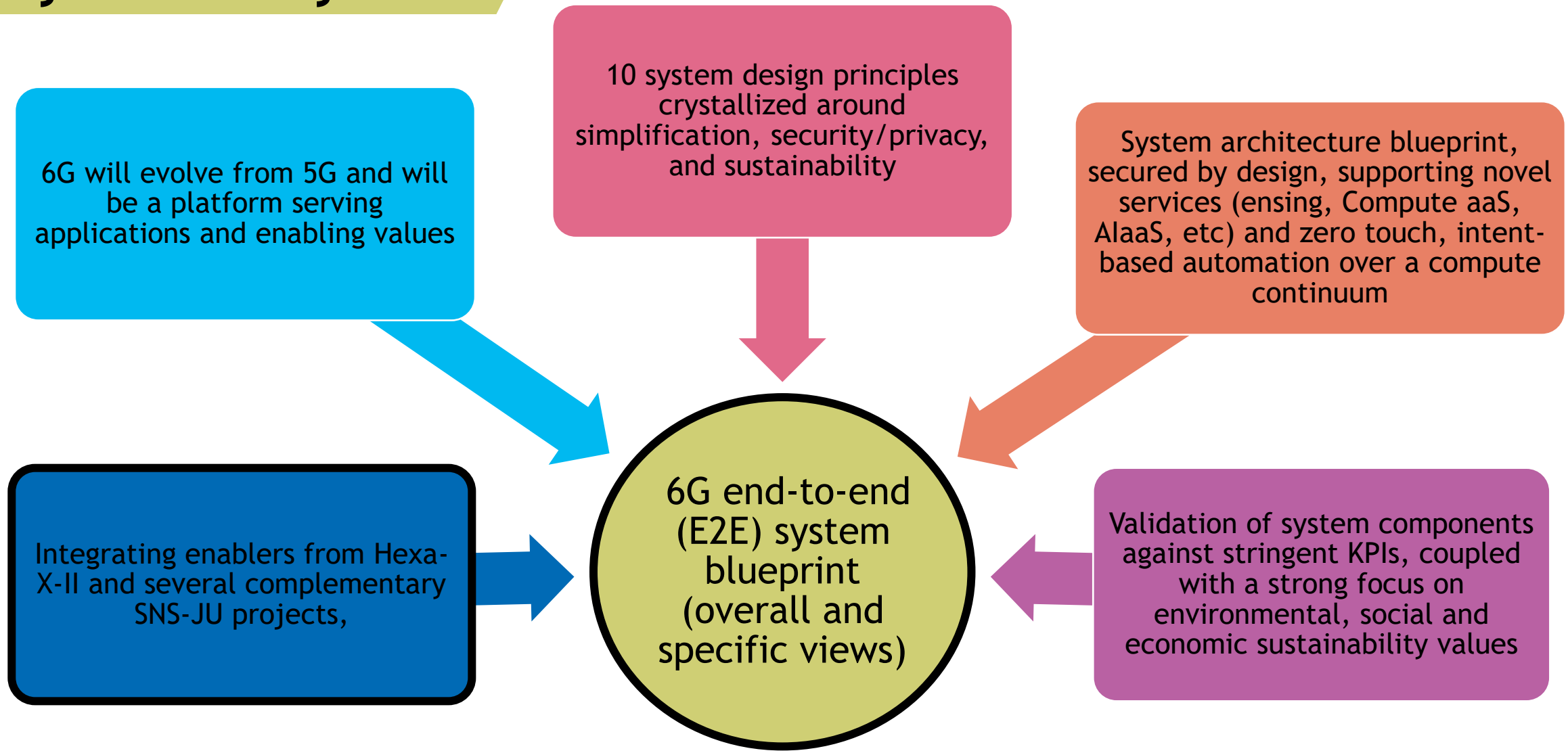








Key take-aways



D2.1, D2.2, D2.3 and D2.4 (soon) WP2 deliverables are available on https://hexa-x-ii.eu/results/

HEXA-X-II.EU //

Co-funded by the European Union

6GSNS

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