NetworkingChannel
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6G Update from Hexa-X and Hexa-X-II

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hexa-x.eu

hexa-x-ii.eu

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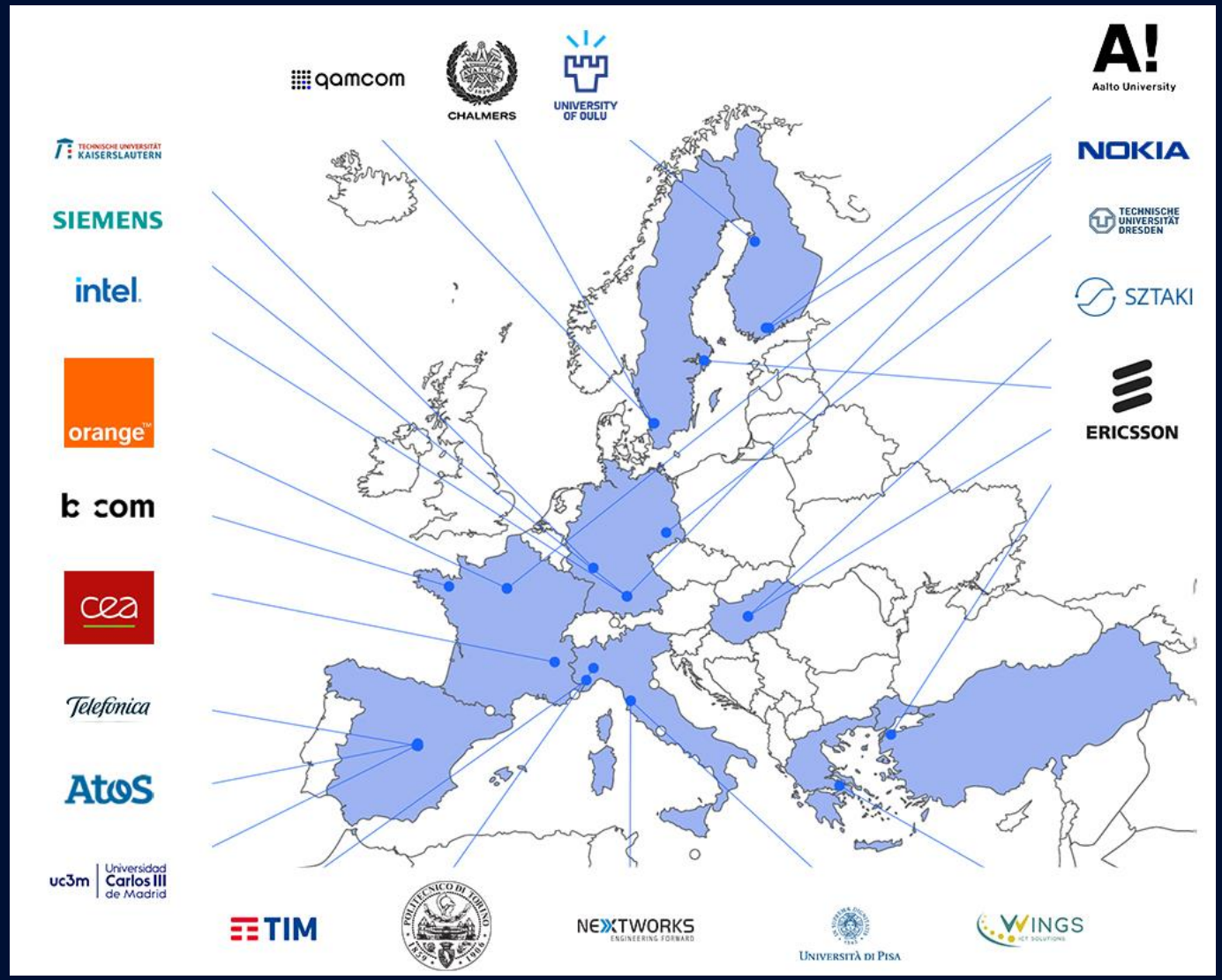
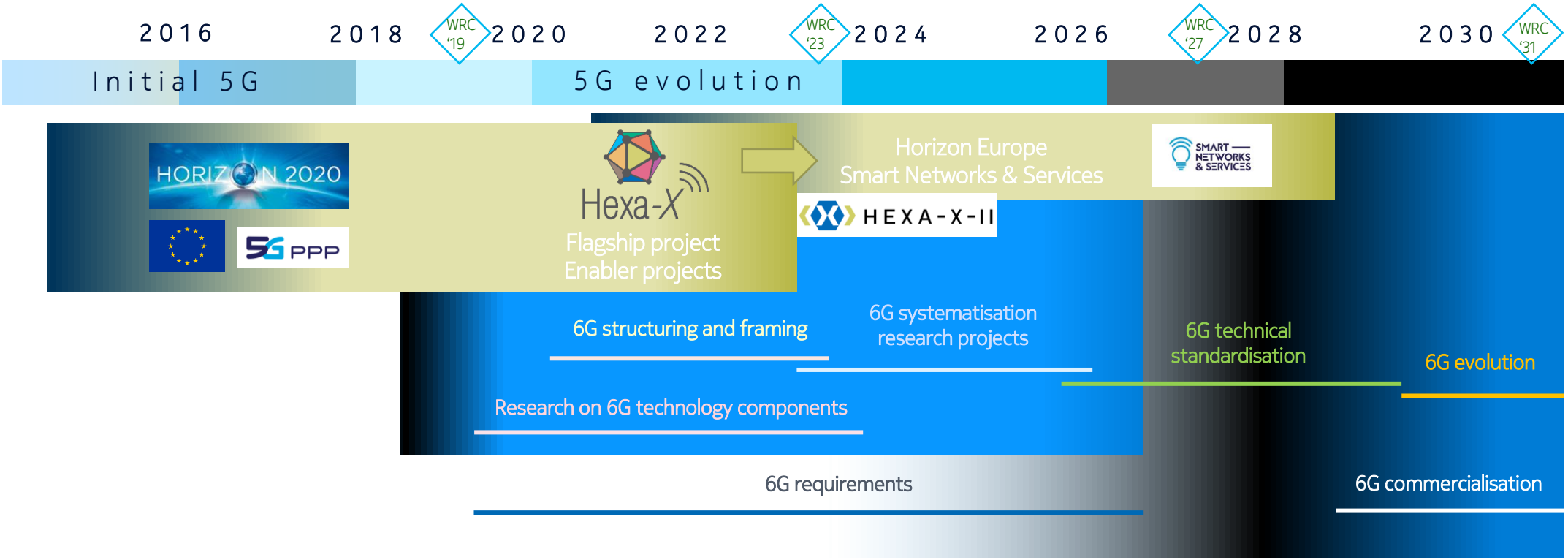
Hexa-X overview

- Hexa-X is the European flagship research initiative to develop the foundation and contribute to industry consensus leading to 6G
- The focus is on structuring, framing, and developing technology for connectivity needs in the 2030 timeframe
- Funded through EU H2020 ICT-52
- 25 partners
  - NW vendors
  - Operators
  - Industry
  - Academia
  - SMEs
- Nokia is overall leader
- Ericsson is technical manager

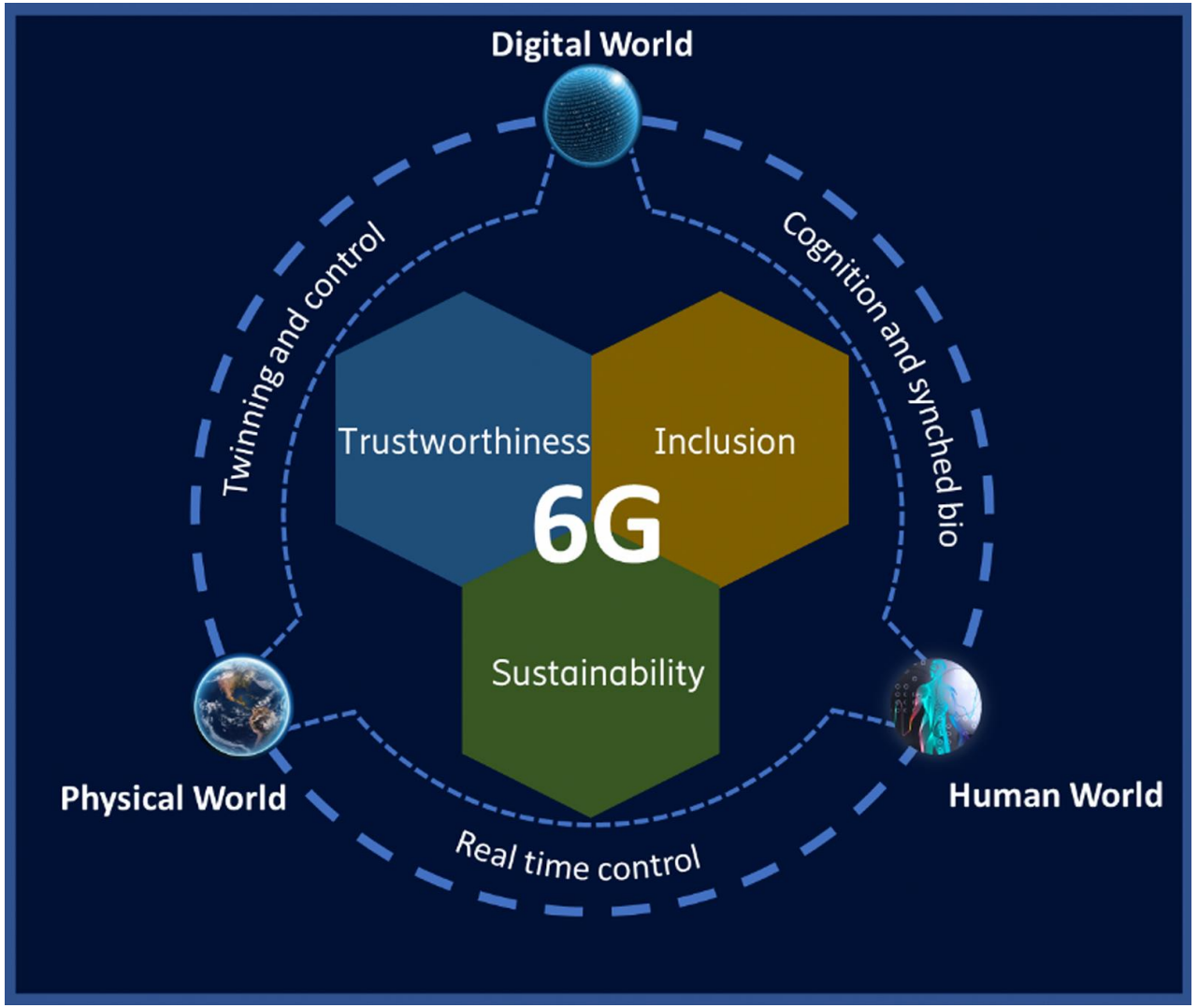


Timeline


2016
2018
WRC '19
2020
2022
WRC '23
2024
2026
WRC '27
2028
2030
WRC '31
Initial 5G
5G evolution
HORIZON 2020
5G PPP
Hexa-X
Flagship project
Enabler projects
Horizon Europe
Smart Networks & Services
SMART NETWORKS & SERVICES
HEXA-X-II
6G structuring and framing
6G systematisation research projects
6G technical standardisation
6G evolution
Research on 6G technology components
6G requirements
6G commercialisation

Hexa-X vision on 6G

- Connecting the physical, digital and human world
- Key values:
  - Sustainability
  - Inclusion
  - Trustworthiness
- Research challenges:
  - Connecting intelligence
  - Network of networks
  - Sustainability
  - Global service coverage
  - Extreme experience
  - Trustworthiness



Hexa-X use cases

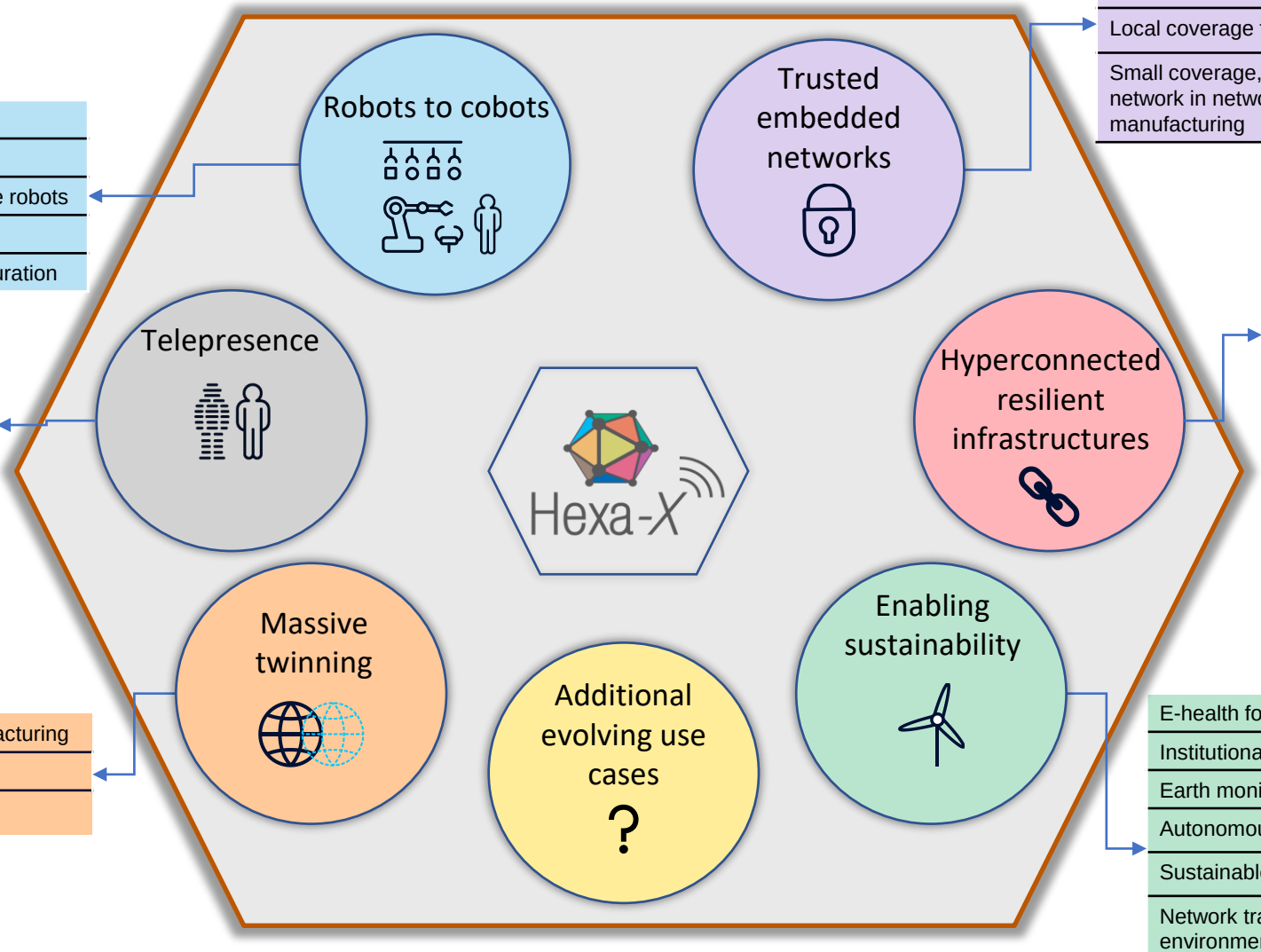
8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION



- Consumer robots
- AI partners
- Interacting and cooperative mobile robots
- Flexible manufacturing
- Situational-aware device reconfiguration

- Human centric communication
- Infrastructure-less network extensions and embedded networks
- Local coverage for temporary usage
- Small coverage, low power micro-network in networks for production & manufacturing

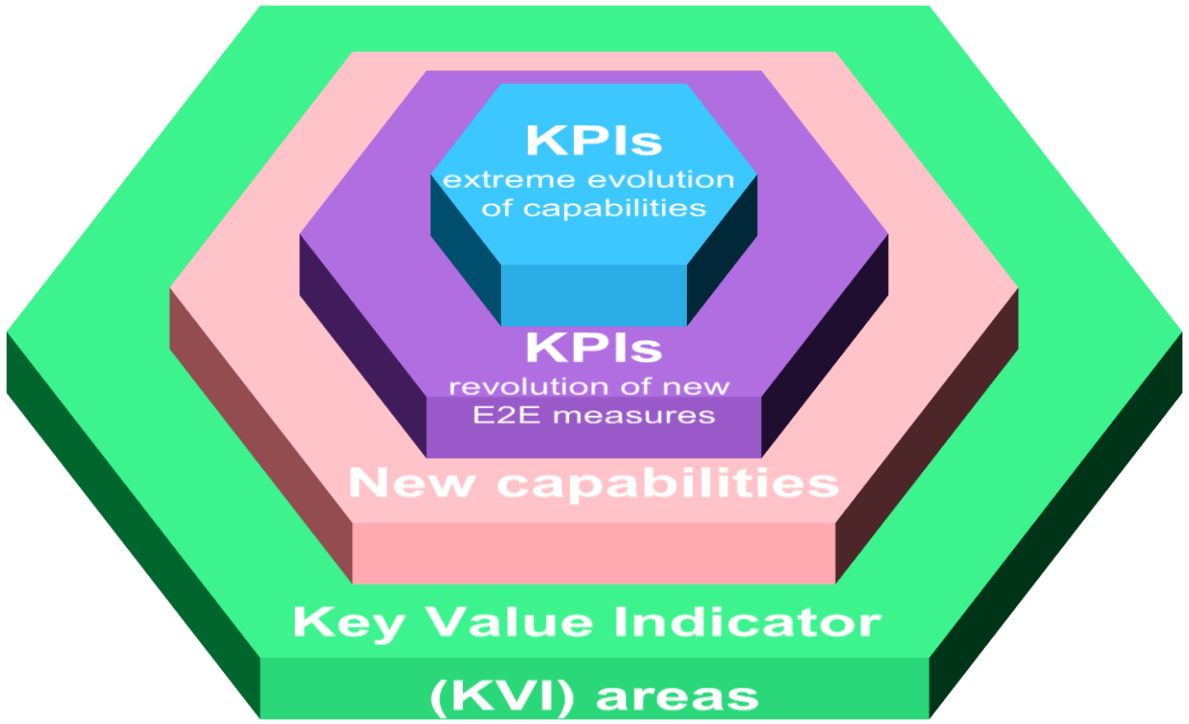
- Fully merged cyber-physical worlds
- Mixed reality co-design
- Immersive sport event
- Merged reality game/ work

- Sensor infrastructure web
- AI-assisted Vehicle-to-everything (V2X)
- Interconnected IoT micro-networks
- Enhanced public protection

- Digital Twins for manufacturing
- Immersive smart cities
- Internet of tags

- E-health for all
- Institutional coverage
- Earth monitor
- Autonomous supply chains
- Sustainable food production
- Network trade-offs for minimized environmental impact
- Network functionality for crisis resilience

Needed capabilities for 6G



Extended KPIs
- Bit rates
- Connection density
- Traffic capacity
- Location accuracy

E2E KPIs
- NW energy efficiency
- Dependability
- Coverage
- Service availability

New capabilities – beyond communication
- Integrated sensing
- Local compute
- Ubiquitous AI
- Embedded devices

KVIs – quantify the human-centric values
- Sustainable 6G
- 6G for sustainability
- Trustworthiness
- Digital inclusion

6G Architecture

Architecture principles

Increased network intelligence

1: Exposure of capabilities to E2E applications

2: Designed for automation

Increased network flexibility

3: Flexibility

4: Scalability

5: Resilience and availability

Increased network efficiency

6: Exposed interfaces are service based

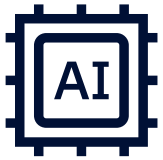
7: Separation of concerns of network functions

8: Network simplification in comparison to previous generations

Architectural enablers

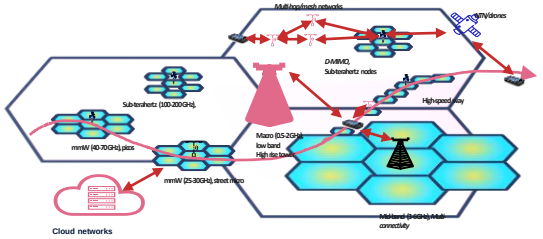
- *Programmability*
- *Network automation, analytics, intent-based management*
- *AI-as-a-Service*

Programmable nodes and devices



Data driven architecture, analytics, network automation

- *Integration of sub-networks*
- *Integration of non-public networks with public networks*
- *Flexible topologies: D2D, mesh, NTN*



Network of networks integration

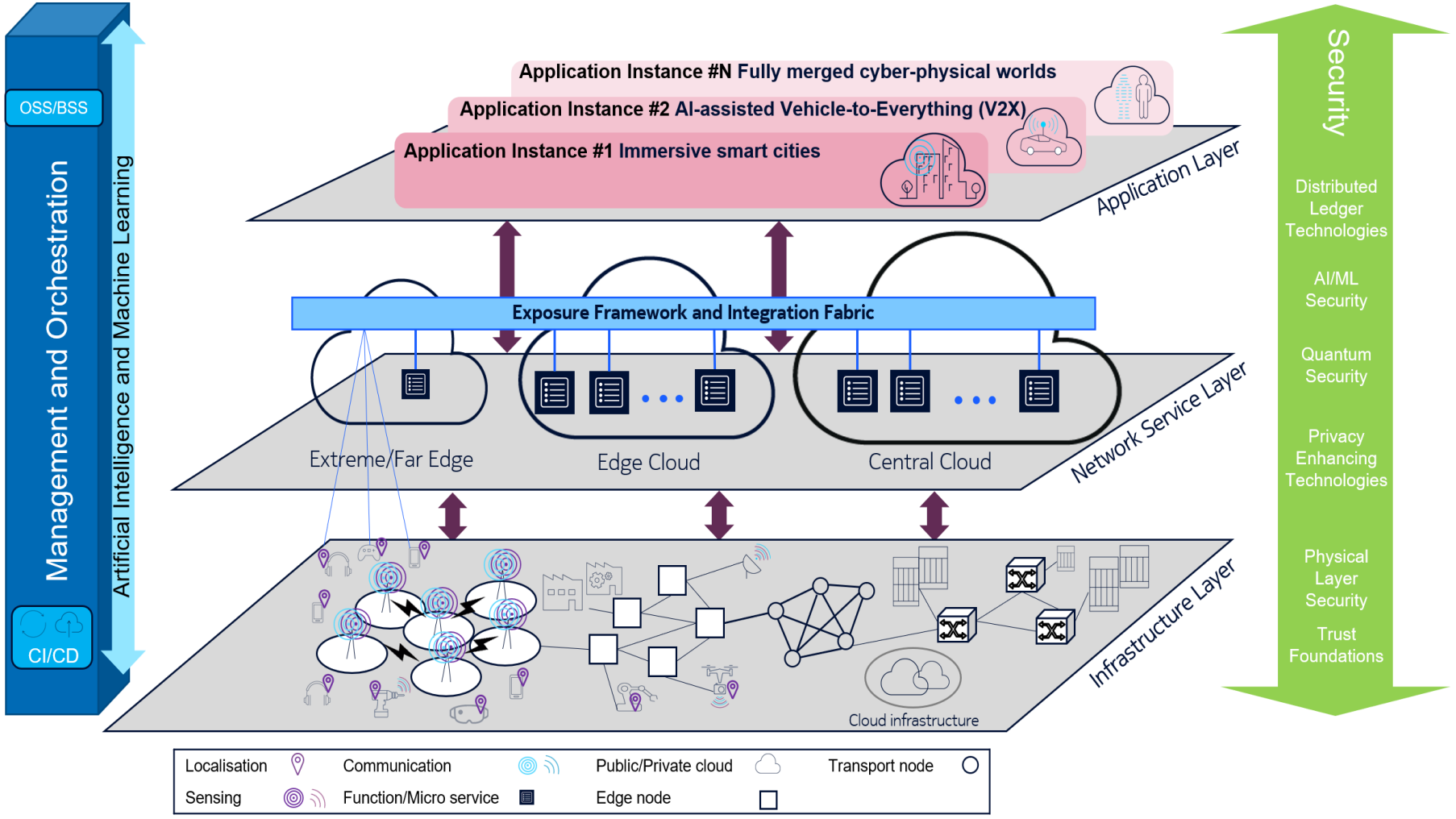
- *Efficient RAN/CN signaling*
- *Function refactoring*
- *Compute-as-a-Service (CaaS)*

Cloud native RAN and CN, dynamic function placement

Energy efficient, Streamline wherever possible

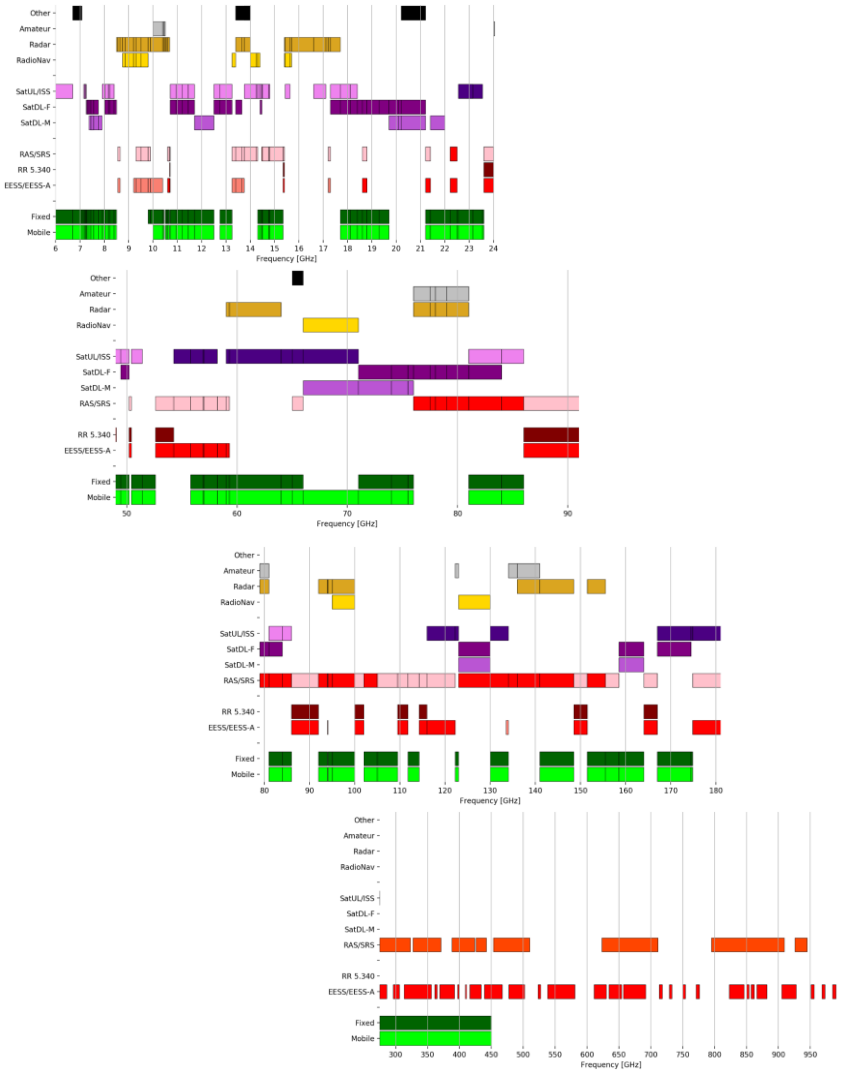
E2E architecture - overview

- First system-level end-to-end 6G architecture.
- It reflects the key technical enablers



Spectrum evolution aspects: Improve spectrum utilization & extend current spectrum boundaries

- Sub-THz spectrum will be utilized with combinations of bands: low, mid, and mmw ranges to optimize wireless link characteristics and cooperatively provide the full set of service requirements
- Spectrum under 6 GHz pivotal for wide area radio coverages
- Possible usage of spectrum in 7-24 GHz range; currently not available for mobile communications to be exploited by proper design of sharing methods with current users
- Improved intelligent spectrum access systems, in particular in newly available spectrum resources in higher bands, to dynamically assign frequency resources to authorised subsystems on both time and geographical basis while preventing interference issues
- Extending spectrum utilization
  - Improving the usage of available spectrum in the different frequency bands identified for IMT
  - New coordination mechanisms and techniques for local spectrum use
  - 6G Networks in Network (NiN) are prospective solutions that can allow interference-controlled operation
  - Improving assumptions and models to better fit more realistic scenarios
  - Introducing sensitivity analyses



An overview of spectrum allocations in several ranges between 6 GHz and 1,000 GHz

Classification of mmW technology by communications & sensing functions

6G mmW technology

(in upper mmW (sub-THz) & lower mmW frequencies)

Short-range wireless links

Small cells & access points, <100m

- Wireless access (D2I)
  - **D2I** at short ranges with low mobility
- Local networks (D2D)
  - **D2D** to disseminate information locally

Long-range wireless links

Front-, mid-, back-haul

- Fixed wireless links
  - When laying **fibre** to extend the reach of wireless networks **is not convenient**
- Mobile wireless links
  - When at least one communication node is moving, **fibre is not possible**

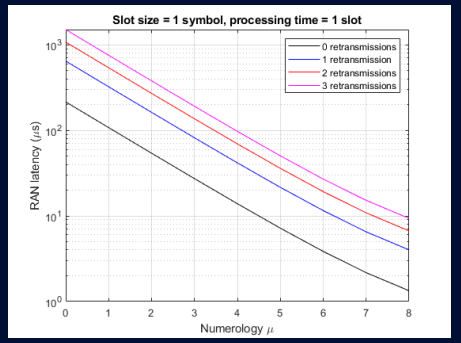
Sensing w/ radio waves

Not “sensor networks”

- Localization
  - Devices obtain accurate location information about **own location**
- Mapping, Tracking
  - Capture the shape of the **environment** or objects/people
- Spectroscopy
  - **Interaction** of EM radiation **with matter**

6G radio targets

Initial estimations of latencies



SCS>480 kHz, Maximum BW 1.96 GHz
→ <0.1 ms RAN latency

(<0.1 ms) RAN latency

(>0.1 Tbps) achievable rate for access

(<1 ms) bounded E2E latency;

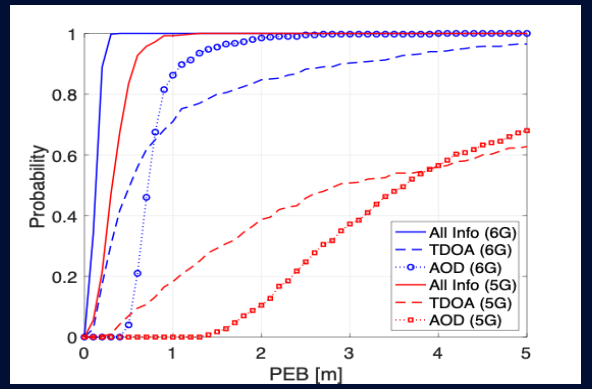
(<1 cm) positioning precision

100 Gbps 6G receiver ADC power consumption model:

Modulation	bits / symbol (b/S), no coding	bits / symbol (b/S), 5/6 coding	RF BW no coding (GHz)	RF BW 5/6 coding (GHz)	BB BW no coding (GHz)	BB BW 5/6 coding (GHz)
BPSK	1	0.83	100.00	120.00	50.00	60.00
QPSK	2	1.67	50.00	60.00	25.00	30.00
16-QAM	4	3.33	25.00	30.00	12.50	15.00
64-QAM	6	5.00	16.67	20.00	8.33	10.00

Deployment specific
e.g., edge-deployed cloud CN in factory setting

Localization in outdoor Urban micro cell



Reimagining purpose of radio connection

Joint communication and sensing

Sensing functionality as an integrated part of the communication network

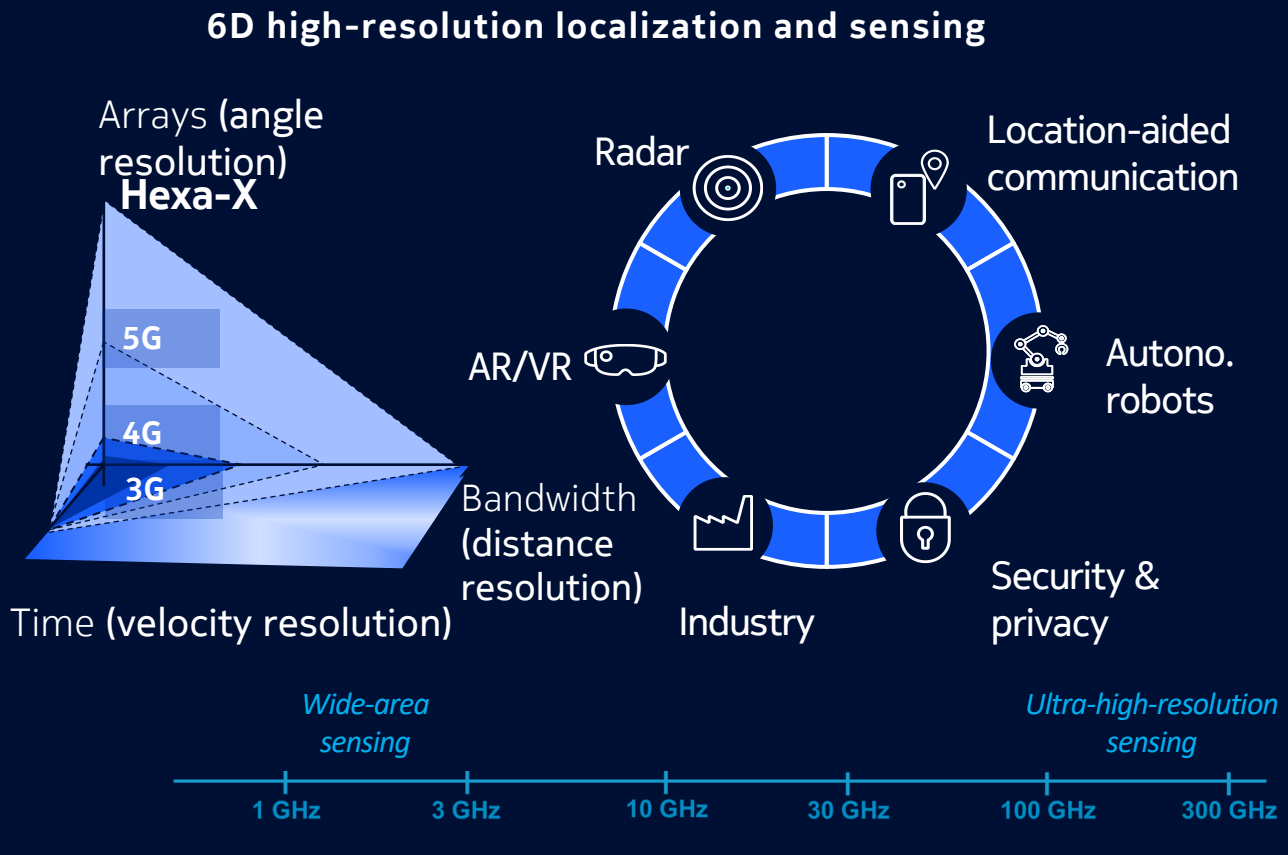
- Low-cost introduction of sensing functionality
- Benefit from huge number of network nodes ⇨ Enhanced sensing capabilities

To enable new and enhanced services

- Location based services
- Emerging services (sensor fusion, AR)

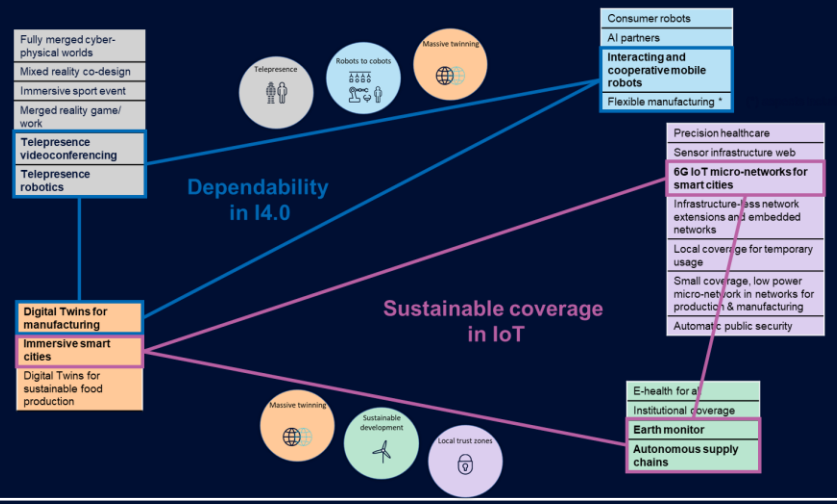
To enhance the network performance

- Simplify beam alignment
- Inter-cell interference coordination
- Pre-emptive radio resource management



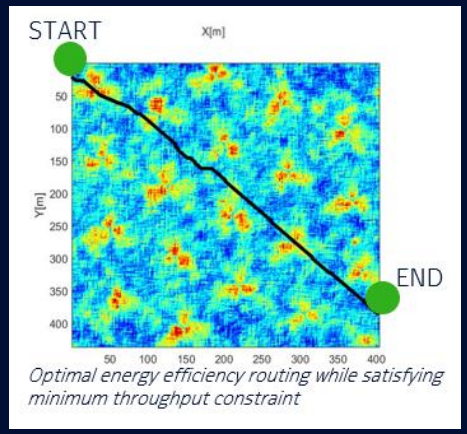
Flexible resource allocation in demanding industrial scenarios

Relevant use cases



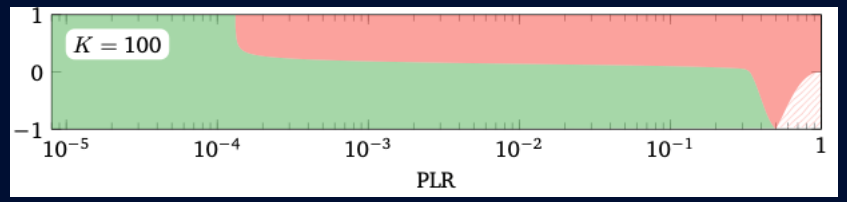
Radio-aware trajectory planning

Radio-aware digital twin
Control UE mobility in industrial environment to optimize performance and energy efficiency



Optimal energy efficiency routing while satisfying minimum throughput constraint

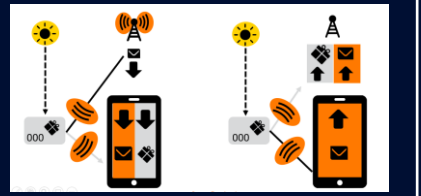
Communication-control-co-design (CoCoCo)



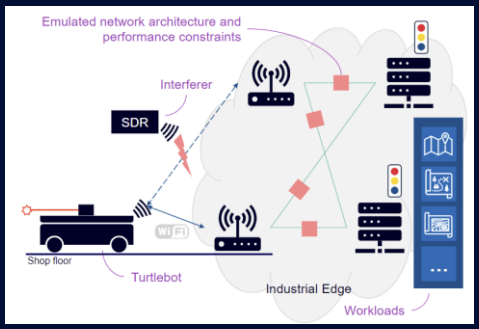
Simultaneously optimize for both communication and control signaling

Crowd detectable zero energy devices

Asset tracking with energy-harvesting
Reporting of location to all nearby phones



Flexible radio mapping



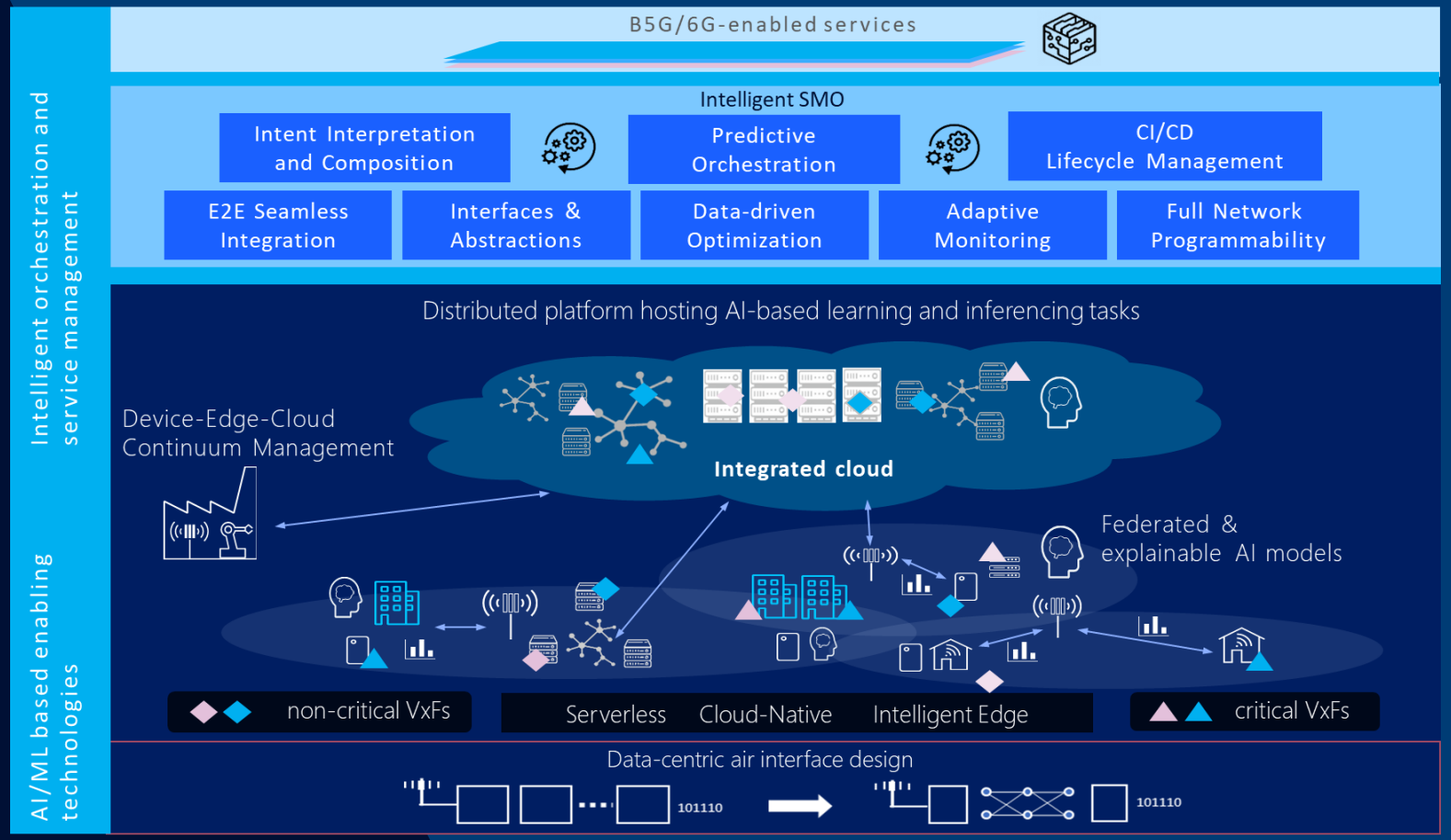
AI-assisted trajectory planning based on forecasted signal strength

Data-driven operation

- **Overall trend:**
  - More and more AI
- **Why this trend? AI can help to:**

  a) Automate management

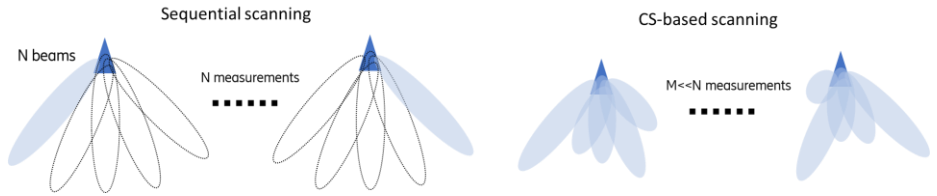
  b) Optimize certain resource or KPIs
- **Consequence of this trend:**
  - AI models everywhere. Models need to be trained. Training requires data.
  - Data needs to be available and secure

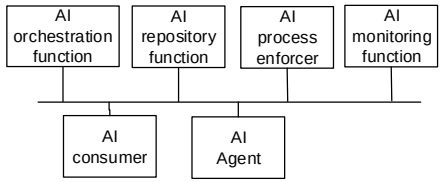


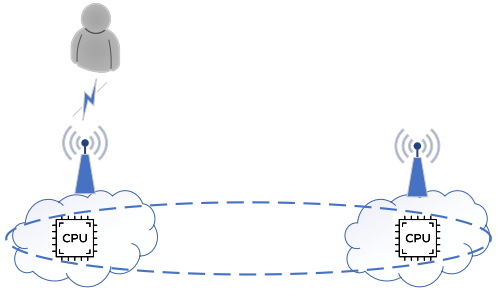
AI-driven communication & computation co-design: initial solutions

Network performance enhancements using AI/ML in 6G

focus: radio access network performance improvements over classical design methods and improvements in E2E network operation & management

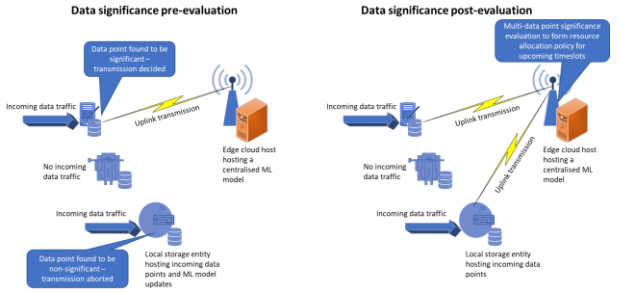






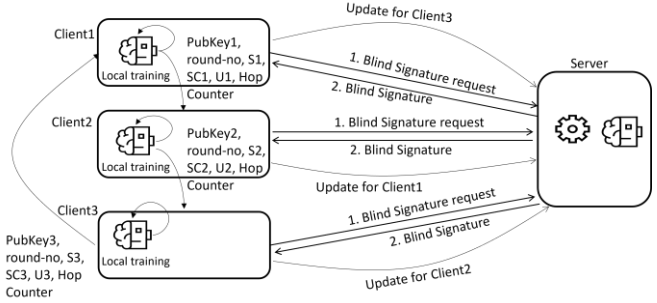
6G network as an efficient AI platform

focus: AI governance, scalable solutions for multi-AI agent learning and communication & compute resource allocation



AI/ML as an enabler for 6G network sustainability

focus: energy efficient in-network AI/ML and complexity reduction gains



Privacy, security & trust in AI-enabled 6G

focus: security and privacy mechanisms for collaborative learning and explainable AI

Conclusion

- 6G will be much broader than the radio-access technology
  A flexible platform providing connectivity, data, compute, intelligence, and sensing
- New results available at hexa-x.eu/deliverables/
  - D1.2 Expanded 6G vision, use cases and societal values – including aspects of sustainability, security and spectrum
  - D1.3 Targets and requirements for 6G - initial E2E architecture
  - D2.2 Initial radio models and analysis towards ultra-high data rate links in 6G
  - D3.2 Initial models and measurements for localisation and sensing
  - D4.2 AI-driven communication & computation co-design: initial solutions
  - D5.2 Analysis of 6G architectural enablers applicability and initial technological solutions
  - D6.2 Design of service management and orchestration functionalities
  - D7.2 Special-purpose functionalities: intermediate solutions

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Hexa-X-II

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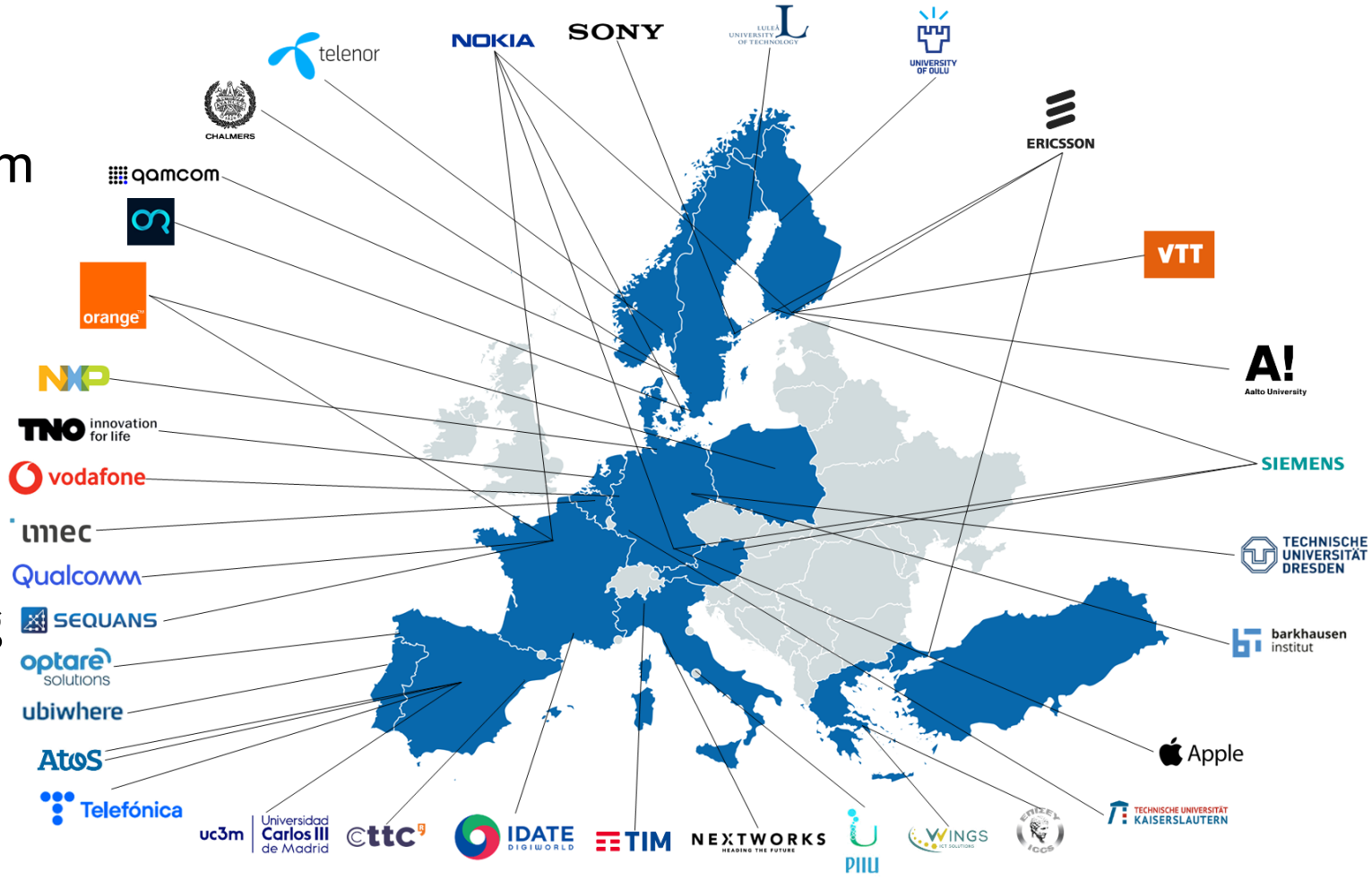
Hexa-X-II

hexa-x-ii.eu

Hexa-X-II overview

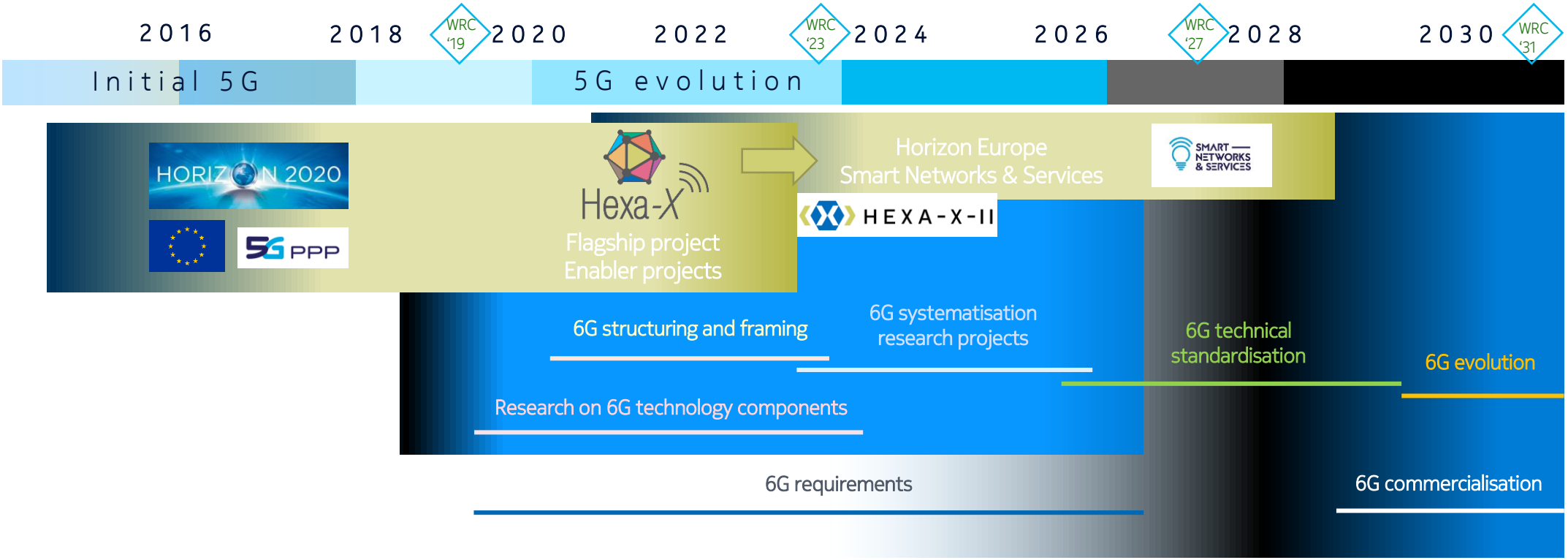
- Hexa-X-II is the next European level 6G Flagship
- Focus will be continued development of technology and define the 6G platform and system
- Funded through Horizon Europe SNS-JU
- 44 partners
  - Cover the entire value-stack from hardware to system to platform to applications to service providers and a strong academic presence
- Nokia is overall leader
- Ericsson is technical manager



Consortium


Service providers
Applications and software
Platform
System and technology
Chipset and hardware
6G ecosystems and offering
TNO
PIILU
orange
TIM
vodafone
Telefónica
telenor
One Reality
optare solutions
ubiwhere
SUITING THE FUTURE
IDATE DIGIWORLD
WINGS ICT SOLUTIONS
NEXTWORKS ENGINEERING FORWARD
SONY
SIEMENS
NOKIA
ERICSSON
Atos
TECHNISCHE UNIVERSITÄT DRESDEN
CHALMERS UNIVERSITY OF TECHNOLOGY
ttc
UNIVERSITY
VTT
ICCS
Aalto University
TECHNISCHE UNIVERSITÄT KAISERSLAUTERN
uc3m
Universidad Carlos III de Madrid
LULEÅ TEKNISKA UNIVERSITET
barkhausen institut
qamcom
imec
SEQUANS COMMUNICATIONS
Qualcomm
NXP
Apple
Academia and RTO
SME
Large enterprise

Timeline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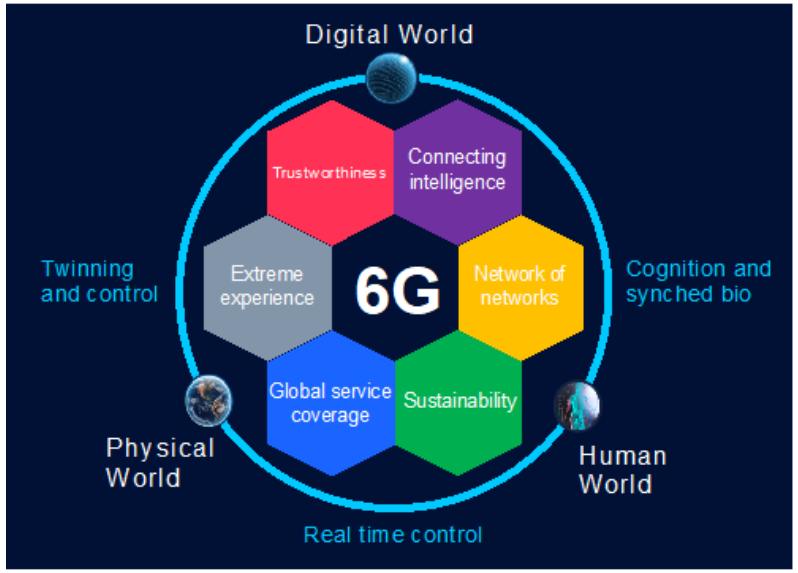
6G requirements
6G commercialisation

Overall objectives of Hexa-X-II

A holistic flagship towards the 6G platform and system to inspire digital transformation for the world to act together in meeting needs in society and ecosystems with novel 6G services

Hexa-X



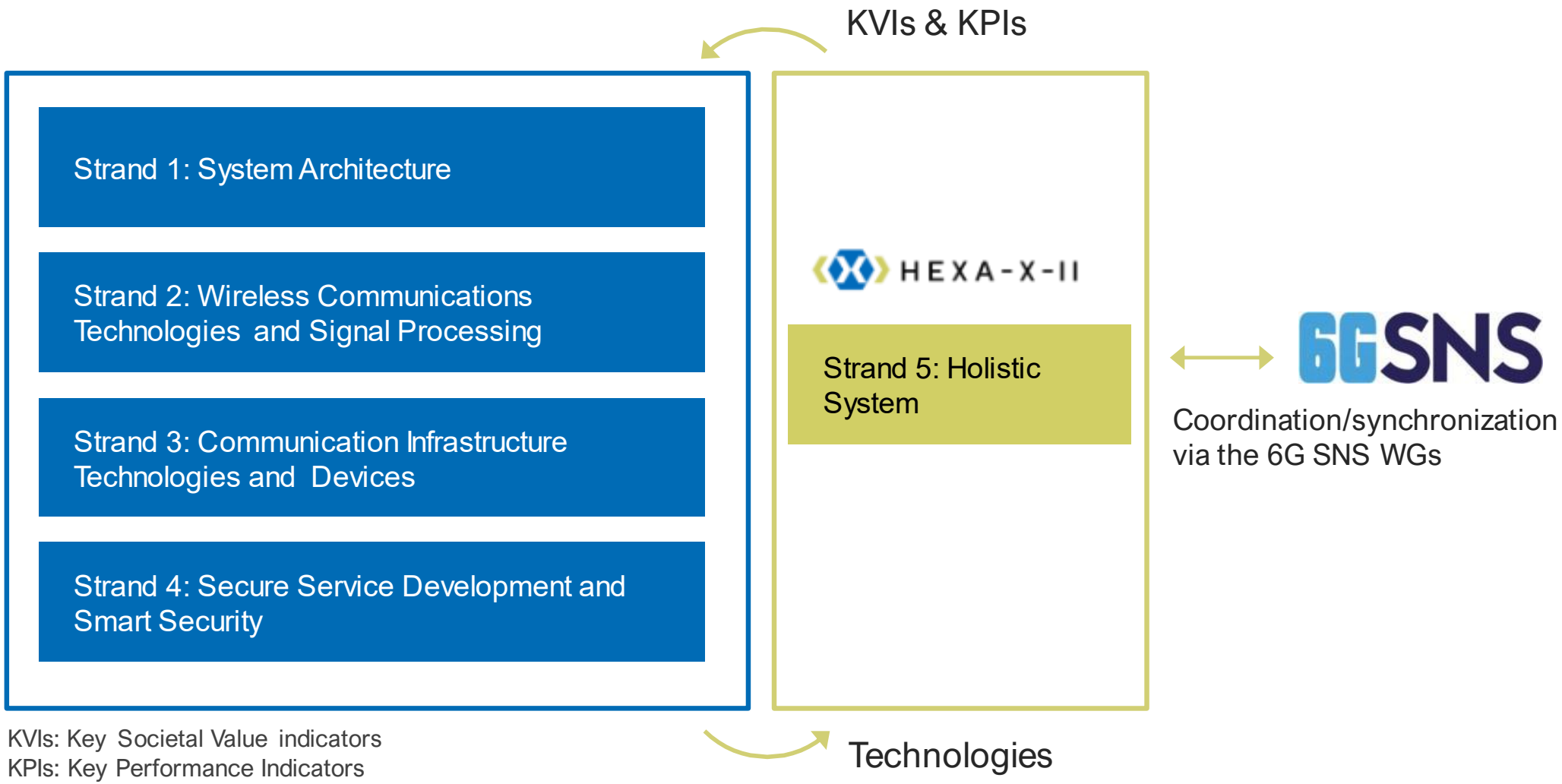
Hexa-X & Horizon-2020 candidate enablers →

HEXA-X-II

6G use cases, services, and requirements	Value for society
6G system blueprint and platform	Global dissemination impact
6G technology readiness	Strategic autonomy

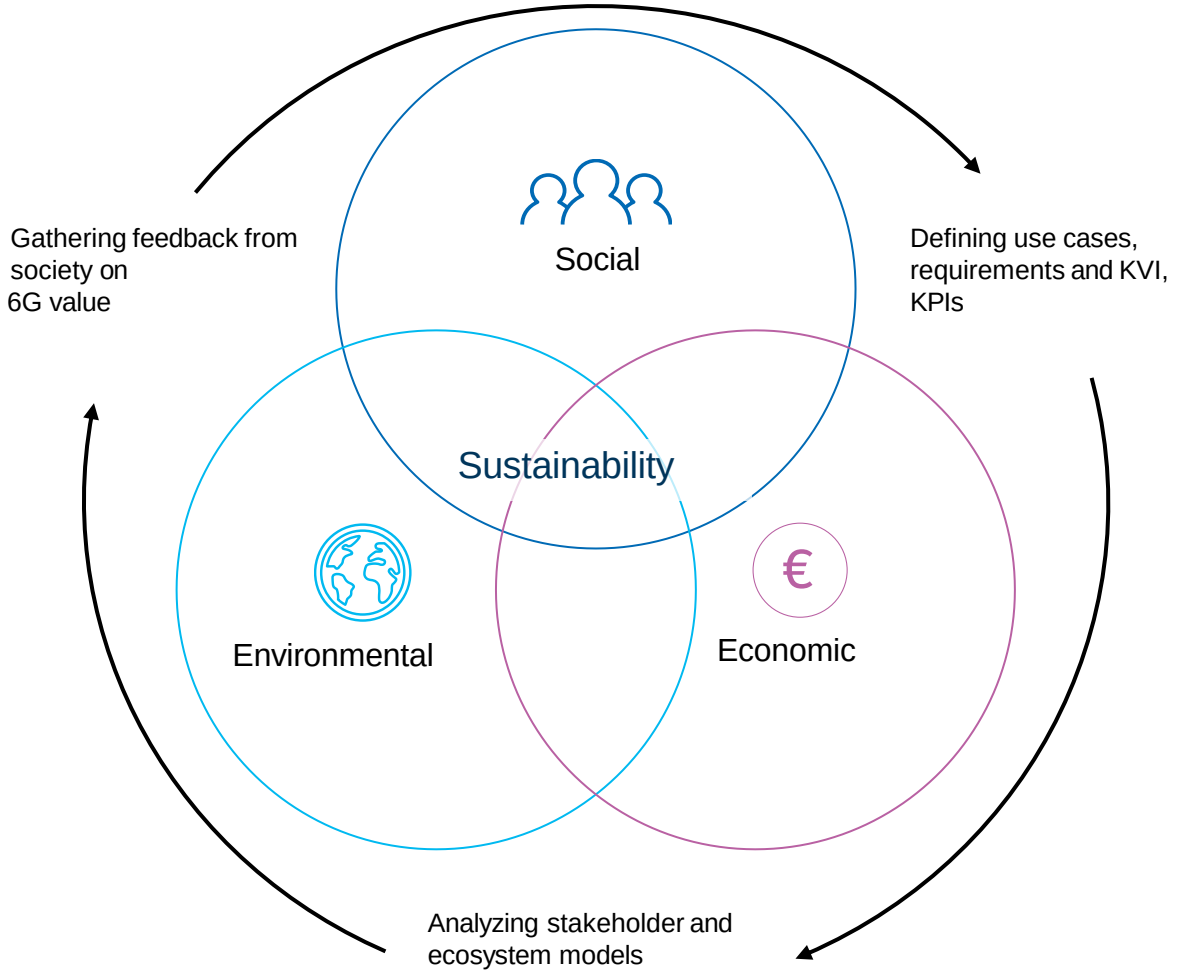
↑ SNS stream B projects

Interactions with other SNS JU projects

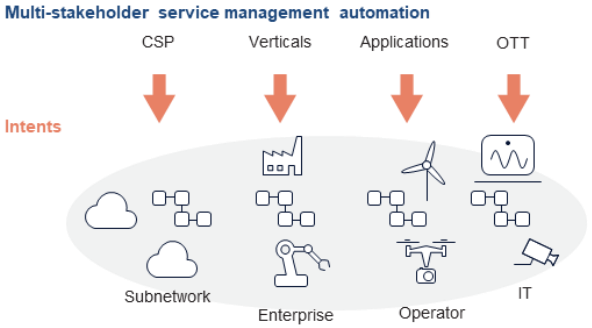


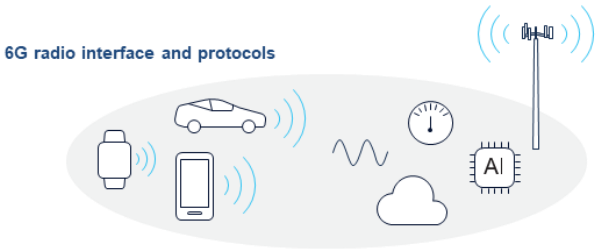
KVIs: Key Societal Value indicators
KPIs: Key Performance Indicators

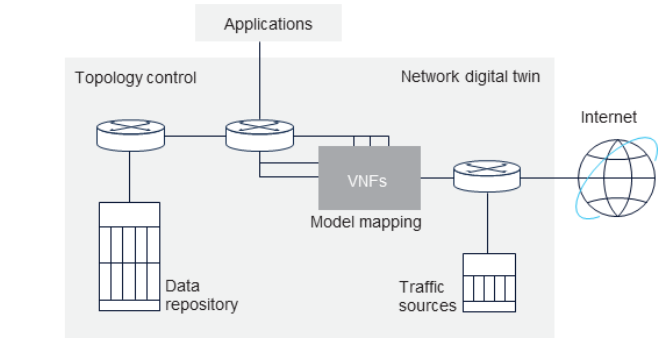
WP1 Value, requirements and ecosystems

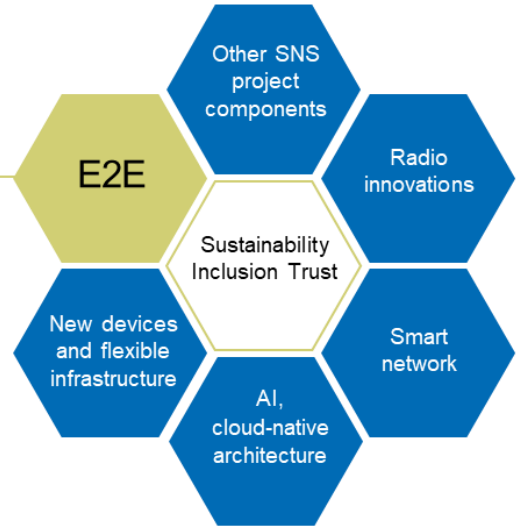


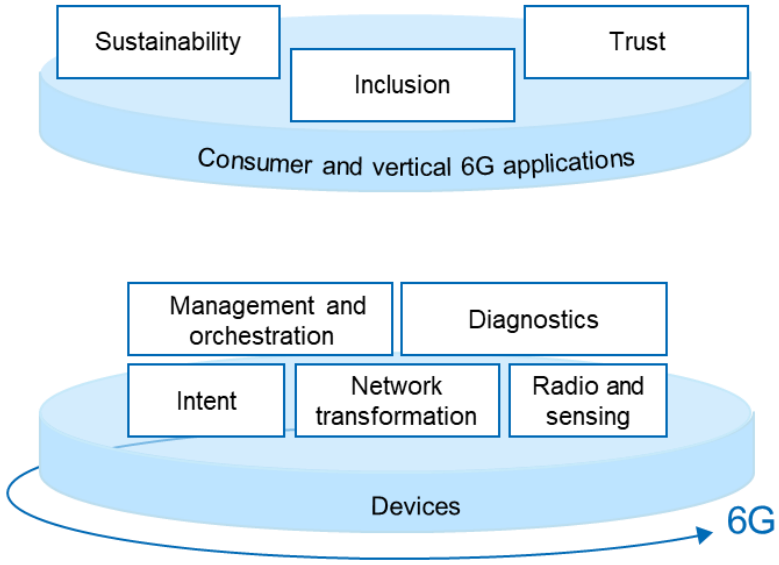
WP2 End-to-end system





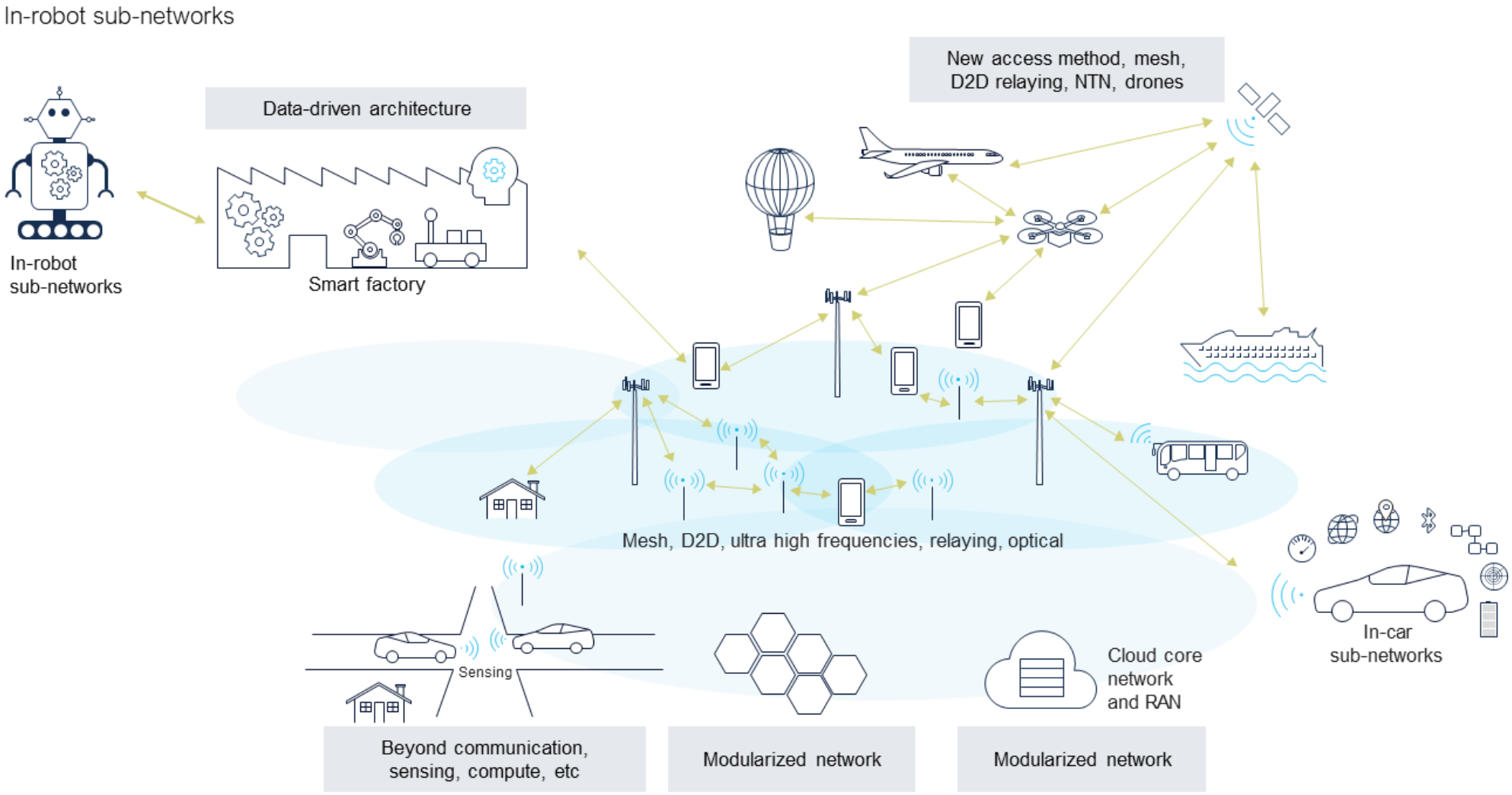






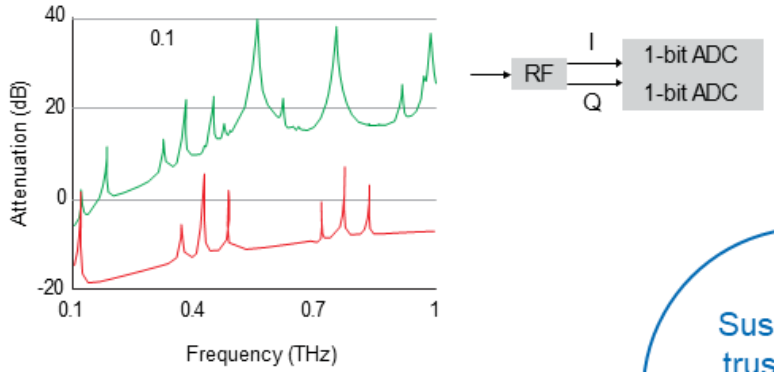
6G network platform blueprint → E2E system validation

WP3 6G architecture design



WP4 Radio evolution and innovation

Towards THz communications

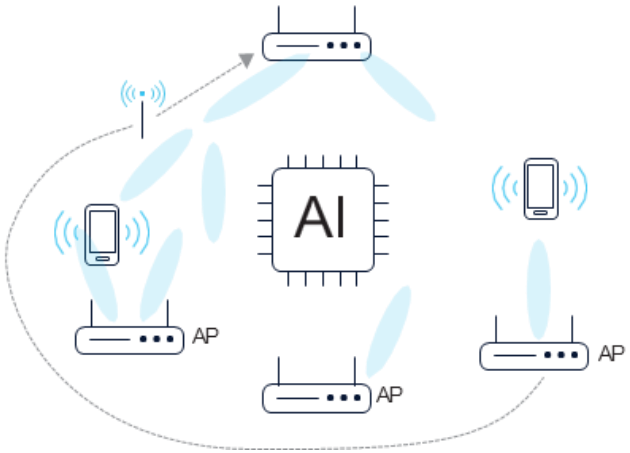


Joint communications and sensing

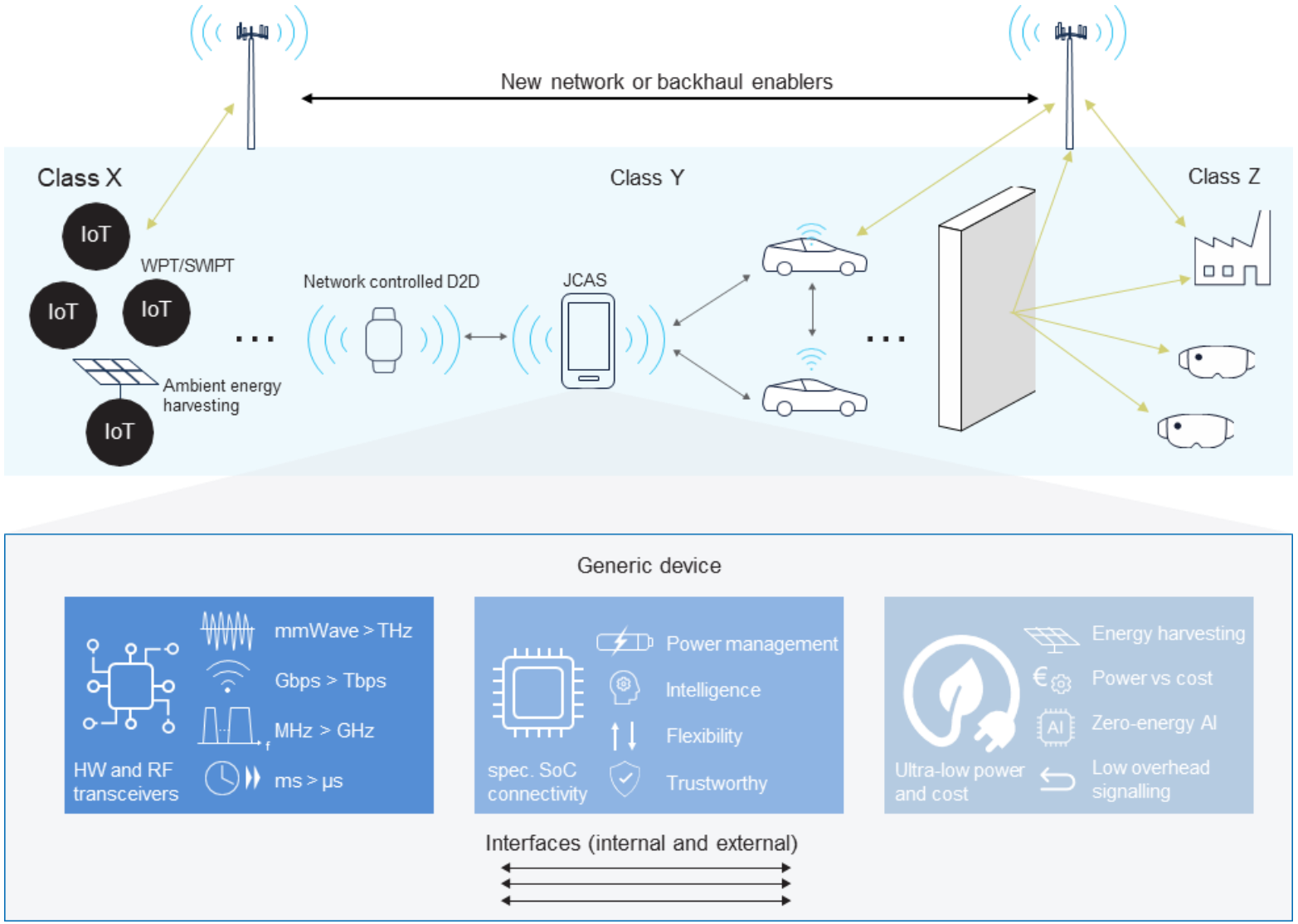
Sustainable, trustworthy, inclusive and holistic radio design

Flexible spectrum access solutions

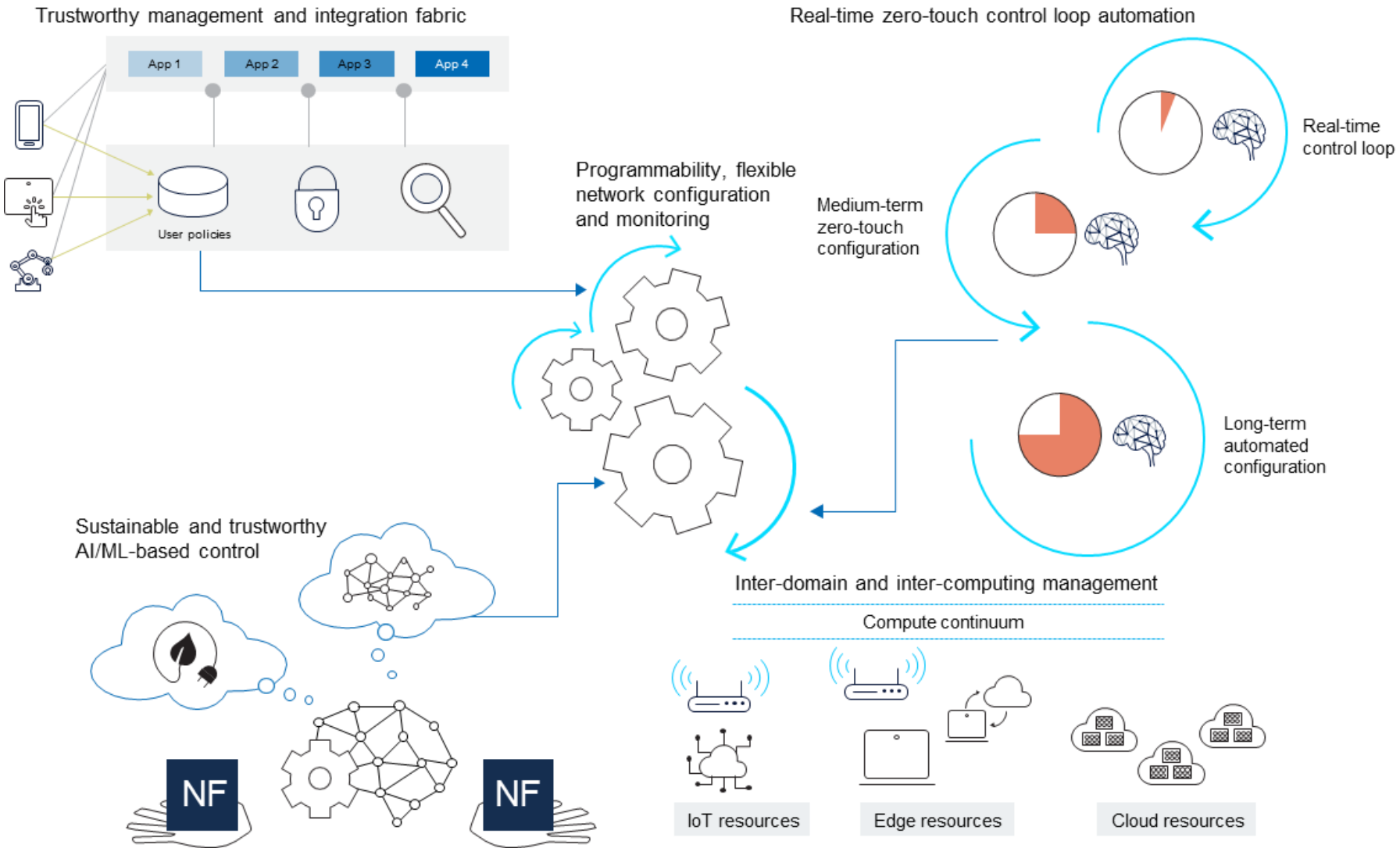
Intelligent radio air-interface design



WP5 Future devices and flexible infrastructure



WP6 Smart Network Management



Deliverables

Id	Deliverable name	Date
D1.1	Environmental, societal and economical drivers and goals for 6G	July 2023
D2.1	Draft foundation for 6G system design	July 2023
D3.2	Initial Architectural enablers	Nov 2023
D4.2	Radio Design and Spectrum Access requirements and key enablers for 6G Evolution	Nov 2023
D5.2	Characteristics and classification of 6G device classes	Nov 2023
D6.2	Foundations on 6G Smart Network Management and Orchestration Enablers	Nov 2023

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6GSNS

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