EUCNC 2022

European 6G Flagship Hexa-X update

hexa-x.eu

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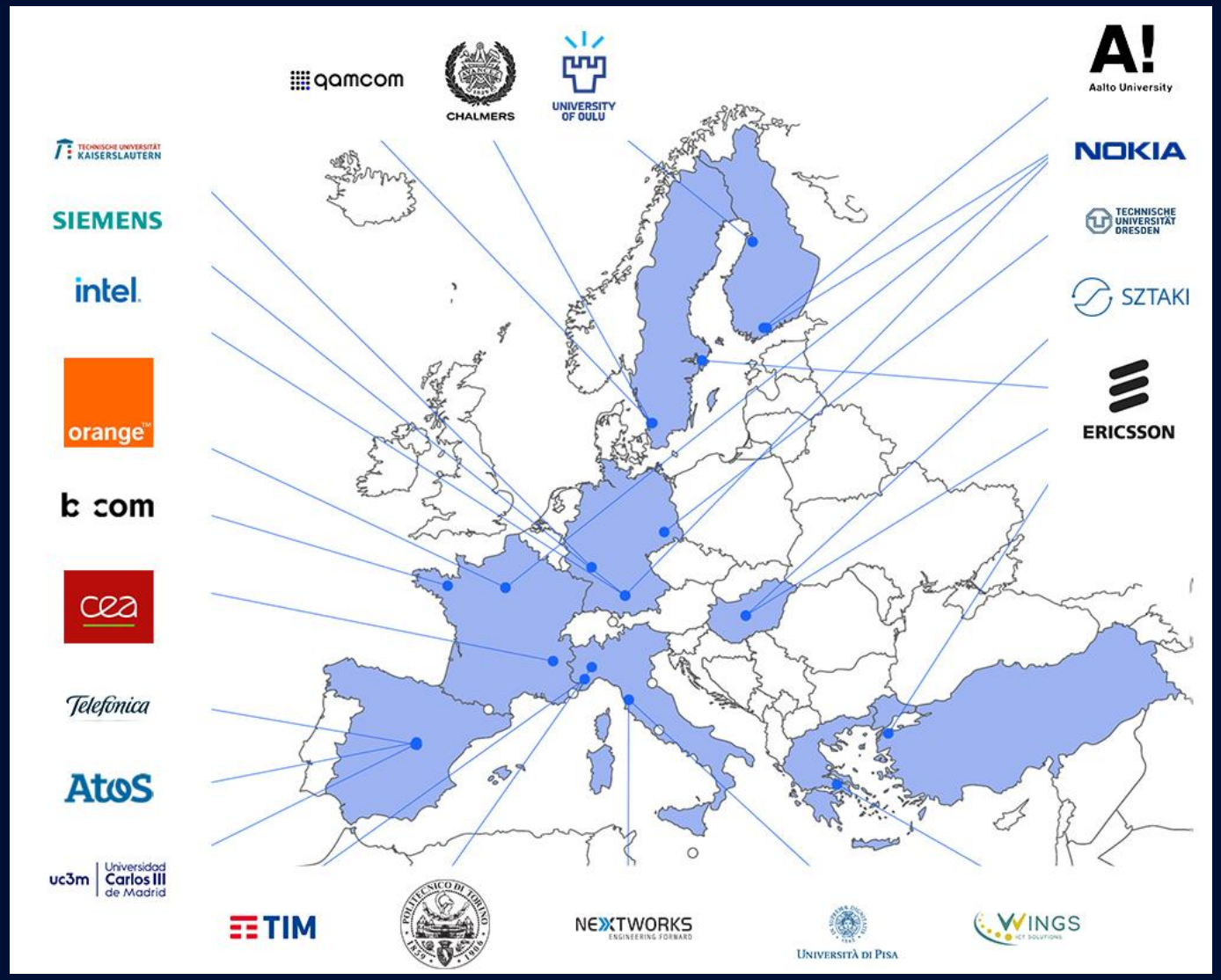
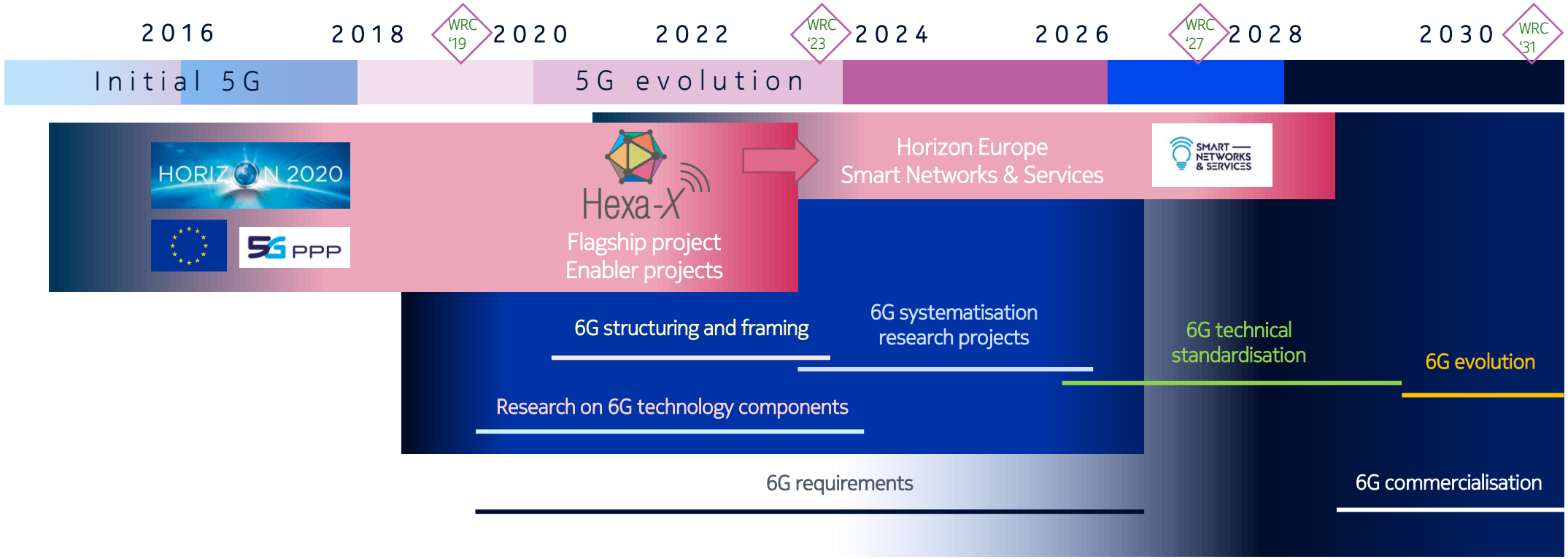
Hexa-X overview

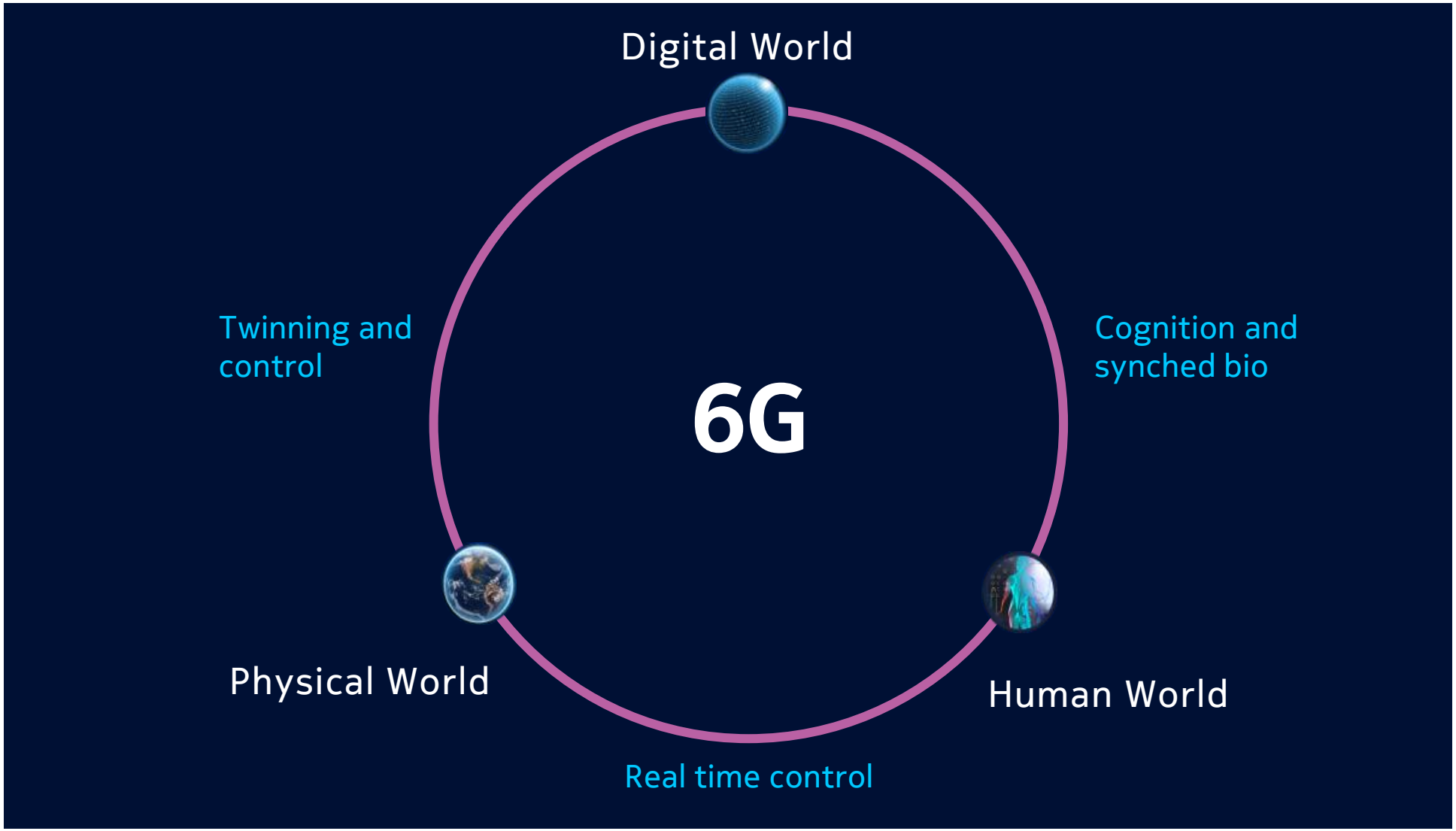
- Hexa-X is the European flagship research initiative to develop the foundation and contribute to industry consensus leading to 6G
- The focus is on structuring, framing, and developing technology for connectivity needs in the 2030 timeframe
- 25 partners
  - NW vendors
  - Operators
  - Industry
  -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



Timeline

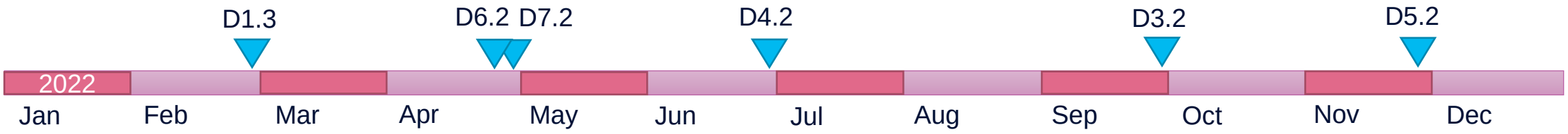

2016
2018
WRC '19
2020
2022
WRC '23
2024
2026
WRC '27
2028
2030
WRC '31
Initial 5G
5G evolution
HORIZON 2020
5G PPP
Hexa-X
Flagship project
Enabler projects
Horizon Europe
Smart Networks & Services
SMART NETWORKS & SERVICES
6G structuring and framing
6G systematisation research projects
6G technical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

Hexa-X Vision



Deliverables 2022

Del. No	Deliverable name	WP	Lead part.	Type	Diss. Level	Del. date
D1.3	Hexa-X architecture for B5G/6G networks – initial release	WP1	NOG	R	PU	M14
D6.2	Design of service management and orchestration functionalities	WP6	ATO	R	PU	M16
D7.2	Special-purpose functionalities: intermediate solutions	WP7	TUK	R	PU	M16
D4.2	AI-driven communication & computation co-design: initial solutions	WP4	OUL	R	PU	M18
D3.2	Initial models and measurements for localisation and sensing	WP3	OUL	R	PU	M21
D5.2	Analysis of B5G/6G architectural enablers applicability and initial technological solutions	WP5	NOF	R	PU	M22



Performance KPI/KVI for 6G radio

Communication

Parameter	First wave 6G radio requirement	Long-term vision for 6G radio
Data rate (R)	100 Gbps	1 Tbps
Operational/carrier frequency (f_c)	100 – 200 GHz range	Up to 300 GHz range
Radio link range (d)	100 – 200 meters	10 – 100 meters
Duplex method	Time Division Duplexing (TDD)	TDD
Initial device class targets	Device to infrastructure, mobile backhaul/fronthaul	Infrastructure backhaul/front haul, local fixed links, and interfaces (data centres, robots, sensors, etc.)

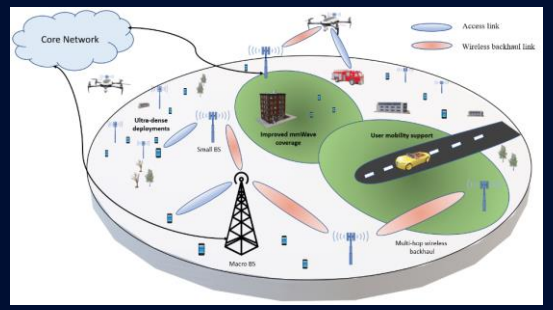
Sensing

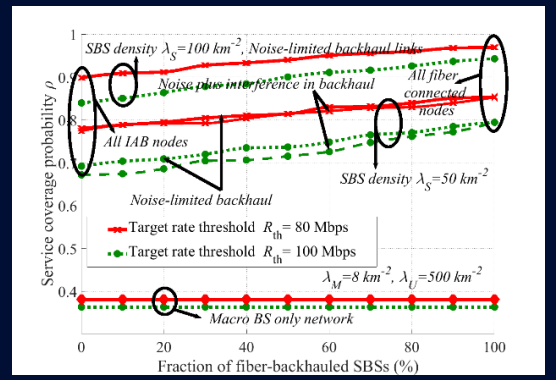
Parameter	Lower range	Upper range
Location accuracy	< 1 cm	1 m
Orientation accuracy	< 1 deg	N/A
Velocity	Stationary	30 km/h
Update rate	Once per millisecond	Once per second
Availabiltiy	2 nines (99%)	7 nines (99.99999%)
Scalability	N/A	100s per m^3

D-MIMO radio architecture studies

Motivation for D-MIMO:
- Mitigate blockage
- Lowering transmit power → further network densification

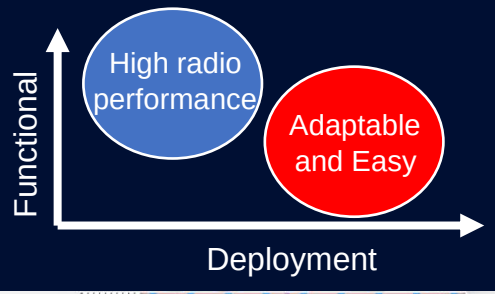
Integrated access and backhauling

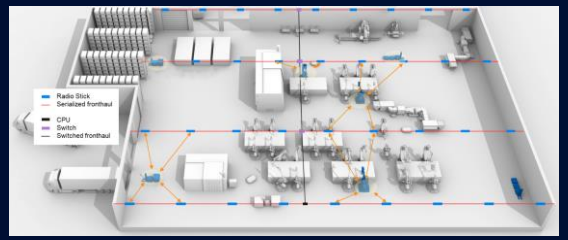




Service coverage probability with integrated access backhauling

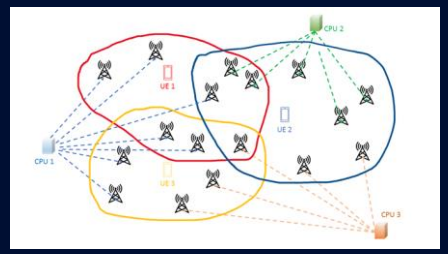
Deployment considerations

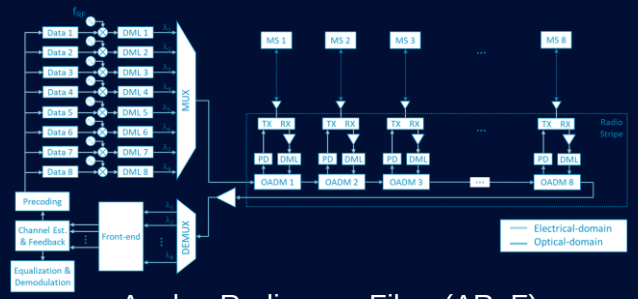




Indoor office deployment

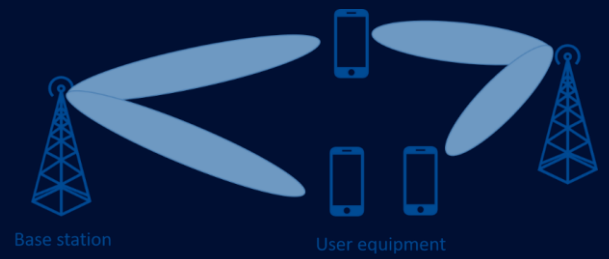
Analog centralized beamforming

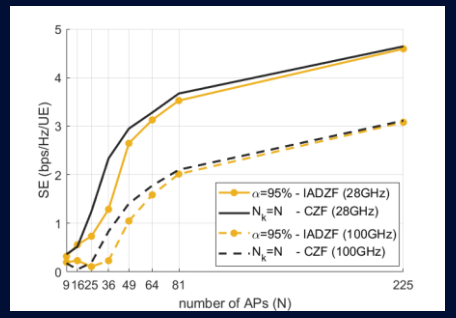




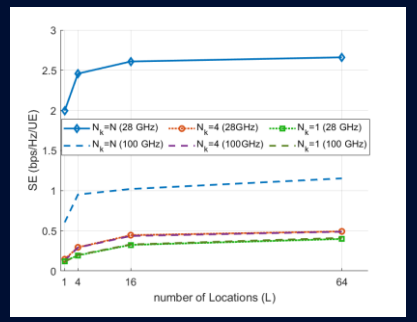
Analog Radio over Fiber (ARoF)

Distributed digital beamforming



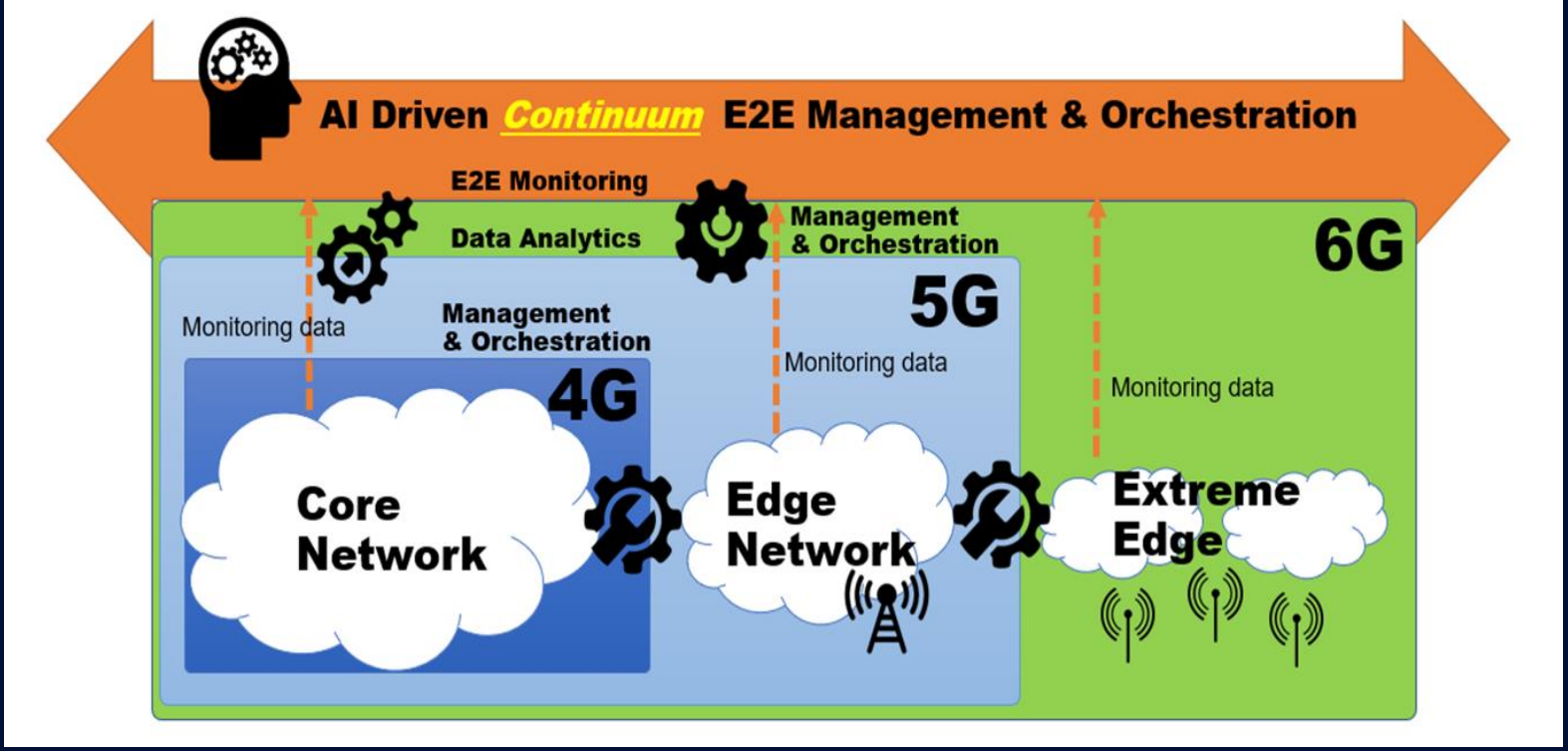


Spectral efficiency comparison of UE-centric and centrally controlled Zero Forcing



Spectral efficiency comparison of collocated and distributed

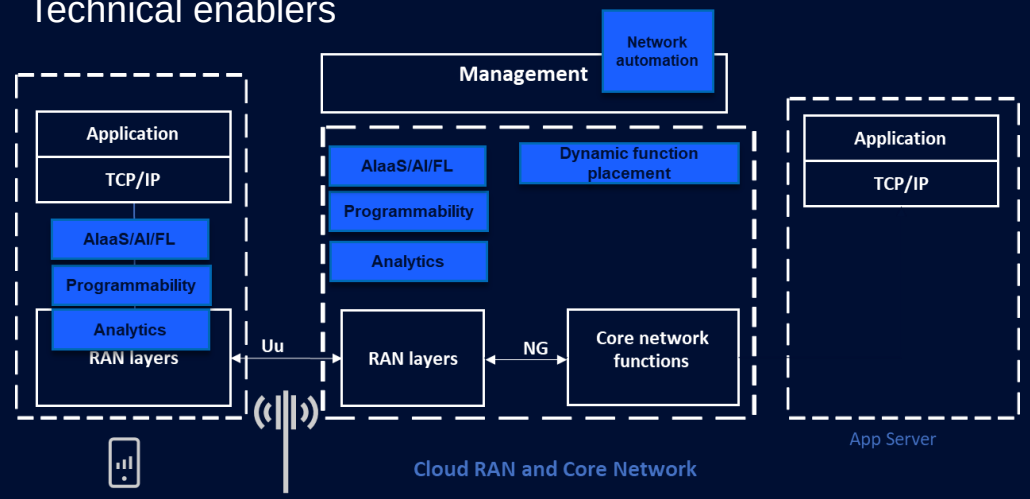
Continuum management of device, edge, RAN, and cloud



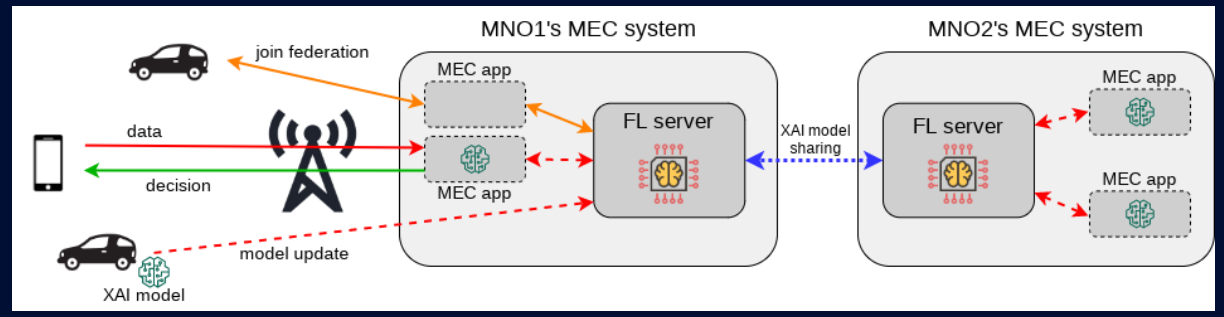
- Orchestration of heterogeneous devices
- Volatile resources with random behavior.
- Devices with limited computing and storage resources.

Integrated and distributed AI and programmability

Technical enablers



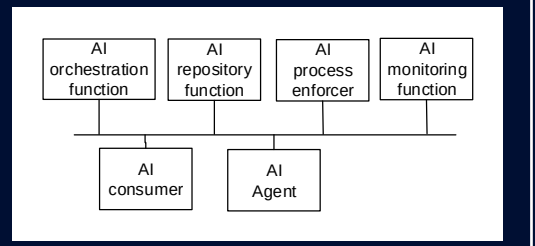
Federated learning and explainable AI services



Design scalable protocols to support:

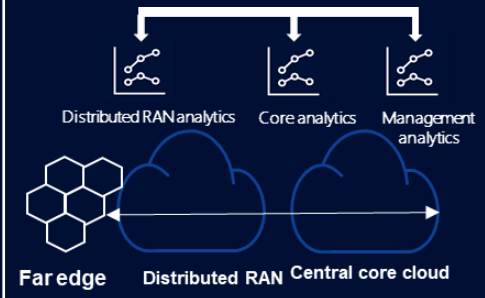
- Joining/leaving a federation
- Update local/global XAI models
- Request/receive explanations for decisions
- Share XAI models among devices/apps

Architecture for AI-as-a-Service



Expose network AI capabilities to 3rd party applications, even at UE side

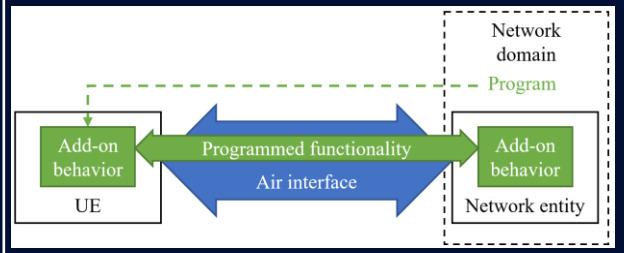
System analytics capabilities



Exchange knowledge and analytics learning between different domains

Will develop methodologies to enable seamless transfer of learnings

Programmability



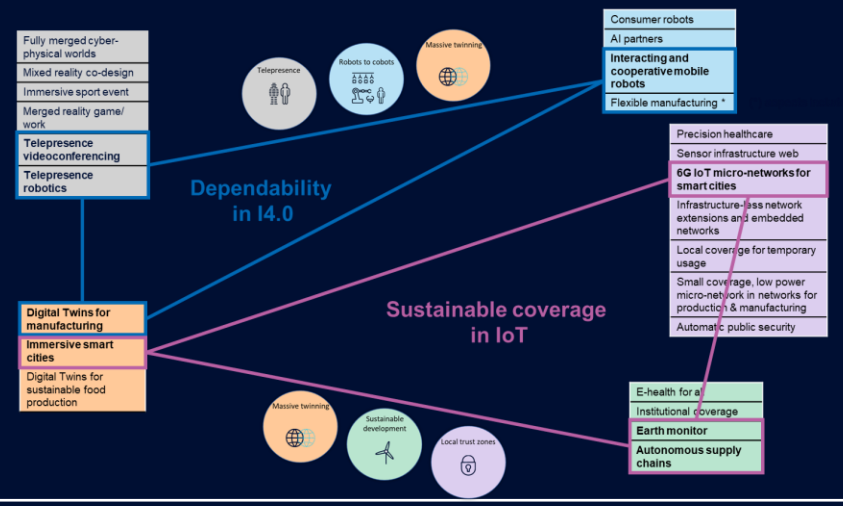
Benefits:
TTM, flexibility, adaptability to new environments

Network programmability:
Dynamic function placement/operation depending on requirements

Programmable UEs:
Tailored industry sensors/IoT devices connected to a dedicated network

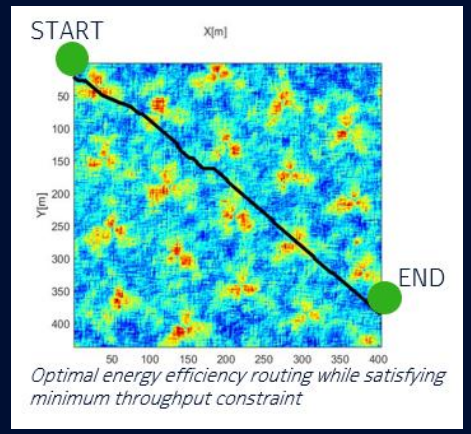
Flexible resource allocation in demanding industrial scenarios

Relevant use cases



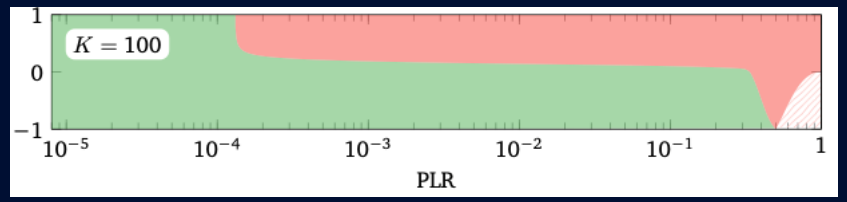
Radio-aware trajectory planning

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

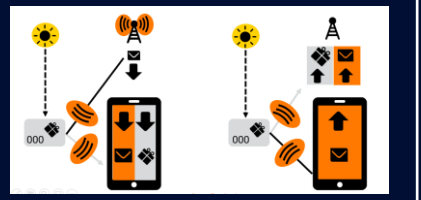
Communication-control-co-design (CoCoCo)



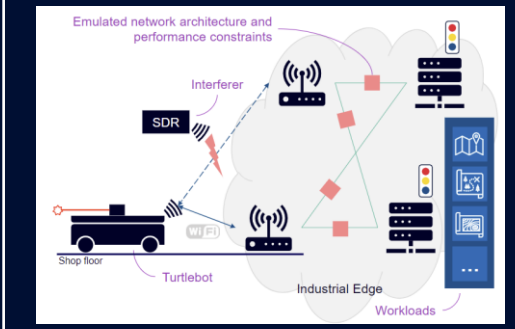
Simultaneously optimize for both communication and control signaling

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

Hexa-X expected impact areas and KPIs

OBJ.1 • Foundations for an end-to-end system towards 6G	OBJ.2 • Radio Technologies towards 6G	Obj. 3 • Connecting Intelligence towards 6G	Obj. 4 • Network Evolution and Expansion towards 6G	OBJ. 5 • Impact creation towards 6G

Performance

At least 0.1 Tbps achievable rate, seemingly infinite network capacity
Less than 0.1 ms RAN latency
Less than 1 ms bounded E2E latency
Less than 1 cm positioning precision
Number of dynamically collaborating AI components in the network (>1000)
Accuracy of an XAI model within (<10%) of “black box” solutions (e.g., DNNs)
Improved network reconfiguration (creation, composition and scaling times) by (>10%)
Improved time to onboard new resources from other domains and manage the addition/removal elements from the network.
Increased service continuity by reduction of downtime by (>80%)

Growth

Boosting of EU connectivity
Acceleration of full digital transformation
Enablement of many more critical applications

Sustainability, Inclusion and Trustworthiness

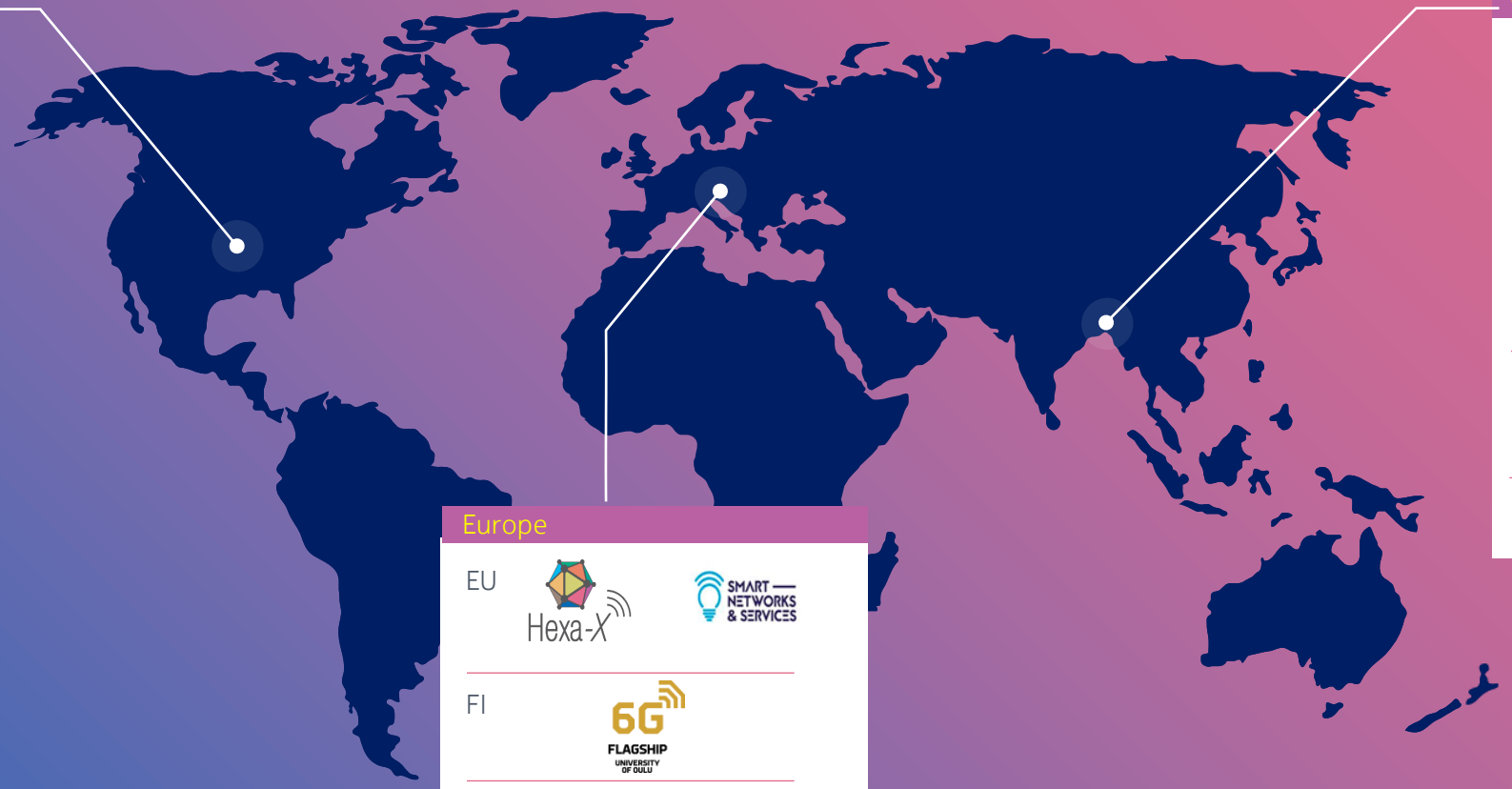
Reduced Total Cost of Ownership
Reduced energy consumption per bit in networks by at least 90%
Reductions of CO_2 emissions by at least 30%
Coverage of at least 99% of global population with at least 1 Mbps
Facilitation of extreme uses and performance in critical contexts
Enhanced resilience/safety of EU society
Increased application reliability
Enhanced security, privacy, accountability

Dissemination and exploitation

Contributions to pre-standardisation groups and industry fora
Patent applications
Participation in industrial exhibitions and events and Business conferences
Small-scale demonstrators
Organisation and attendance of Hexa-X industrial workshops
Participation to 5GPPP and Smart Networks and Services Programme activities
Organisation of scientific events
Publications, press-releases
Project web-site and strong social media presence

6G Ecosystem

Hexa-X



North America

NEXT G ALLIANCE

NSF RINGS

Europe

EU

Hexa-X

SMART NETWORKS & SERVICES

FI

6G FLAGSHIP UNIVERSITY OF OULU

DE

BMBF

6G Hubs

Asia

CN

MIIT

中华人民共和国科学技术部 Ministry of Science and Technology of the People's Republic of China

未来移动通信论坛 FUTURE MOBILE COMMUNICATION FORUM

KR

Ministry of Science and ICT

5G Forum

JP

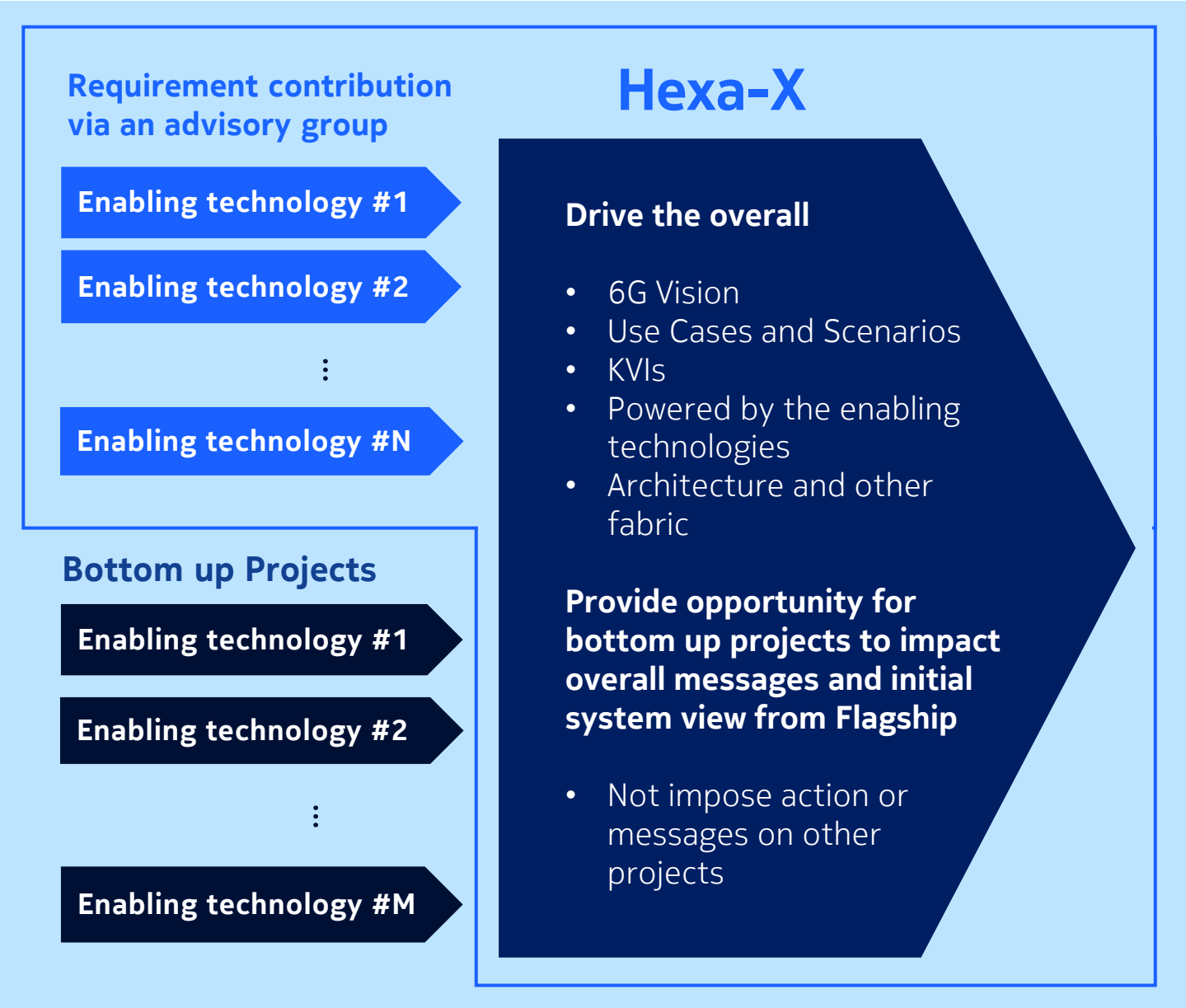
MIC Ministry of Internal Affairs and Communications

IOWN GLOBAL FORUM

IN

tsdsi

Relation of Hexa-X to other 6G research projects (left), and to major stakeholders (right).



Conclusion

- Hexa-X will pave the way to the next generation of wireless networks (Hexa) by explorative research (X).
- Hexa-X is in a great position to strengthen the competitivity and other societal goals of Europe
- The Hexa-X vision is to connect human, physical, and digital worlds with a fabric of 6G key technology enablers.
- 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/

- Recording of ICT-52 workshop on 6G
- 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
- D3.1 Localisation and sensing use cases and gap analysis
- D4.1 AI-driven communication & computation co-design: Gap analysis and blueprint
- D5.1 Initial 6G architectural components and enablers
- D6.2 Design of service management and orchestration functionalities
- D7.2 Special-purpose functionalities: intermediate solutions

- Note also e.g. M. A. Uusitalo, P. Rugeland et al, “6G Vision, Value, Use Cases and Technologies from European 6G Flagship Project Hexa-X”, IEEE Access, Nov 2021

Thank you!

HEXA-X.EU

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