EMPOWER Panel March 2022

European 6G Flagship Hexa-X

hexa-x.eu

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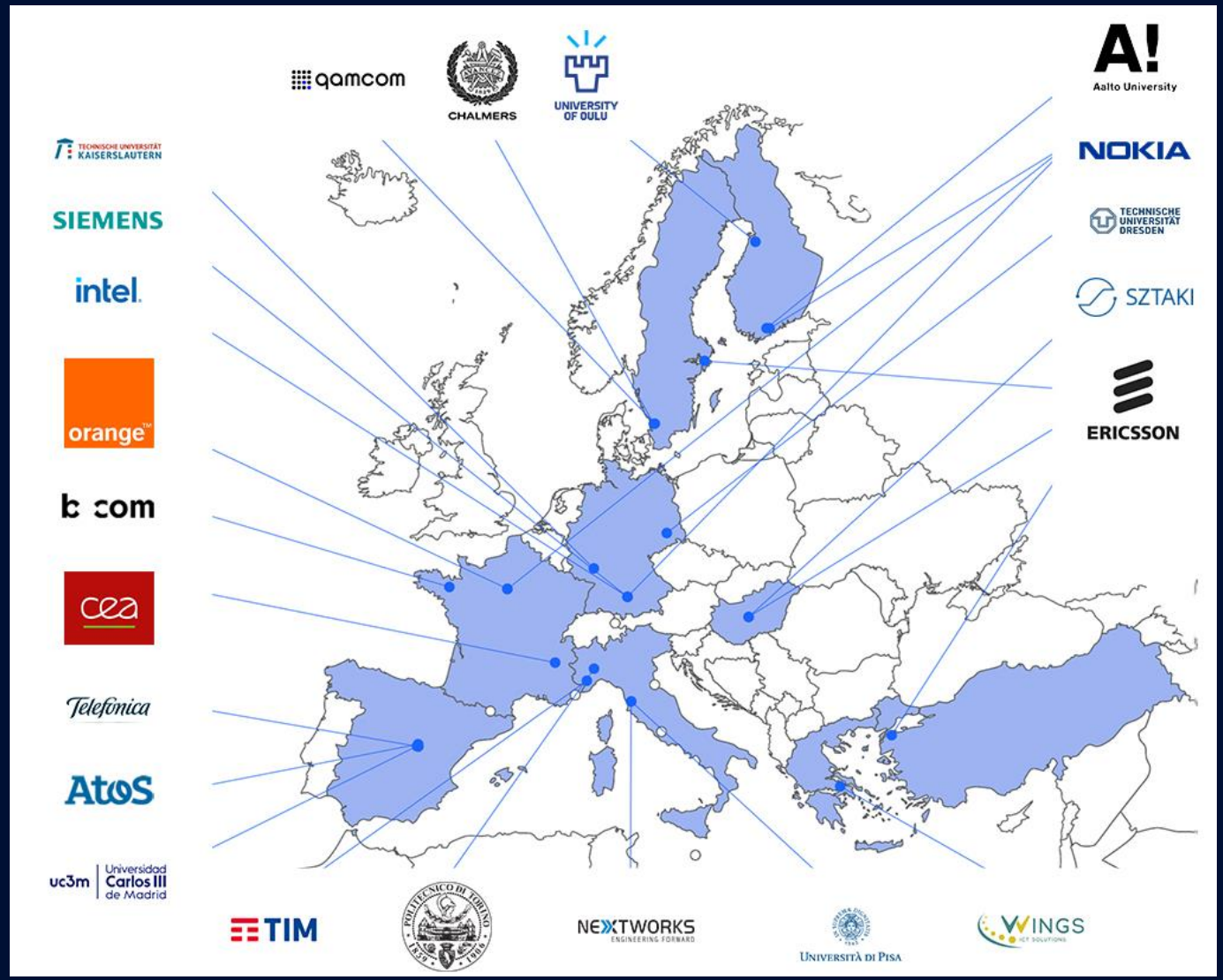
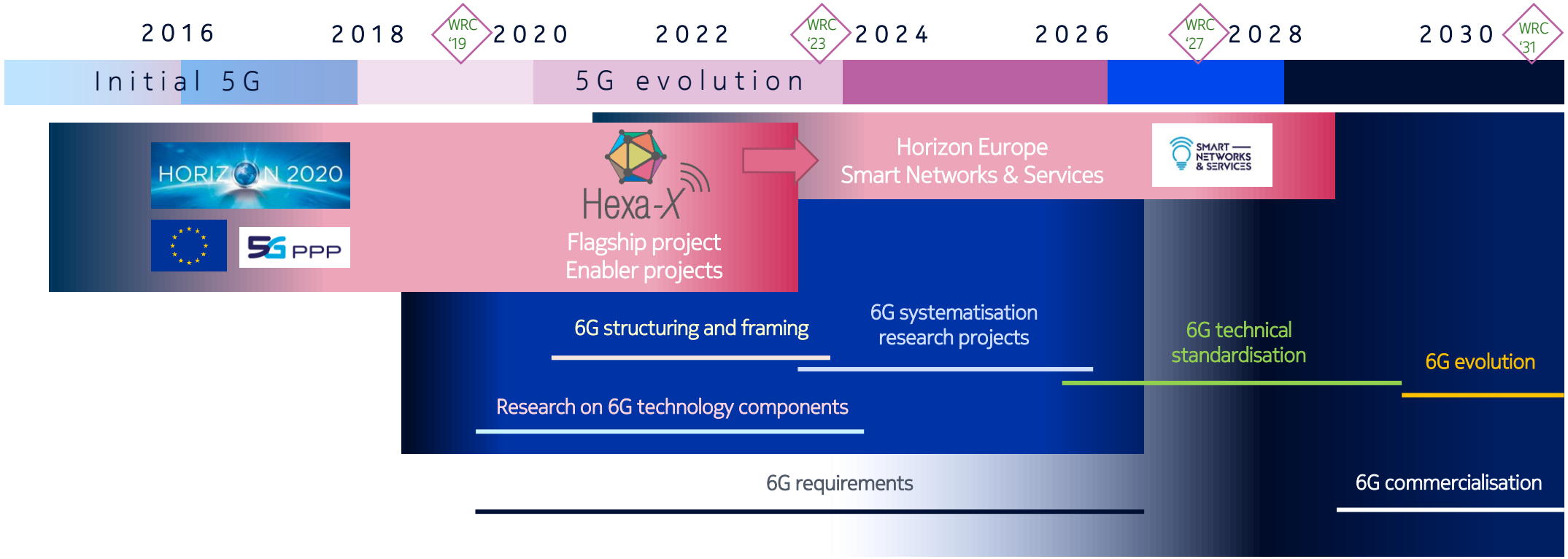
Hexa-X overview

- 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
- Funded through EU H2020 ICT-52
- 25 partners
  - NW vendors
  - Operators
  - Industry
  - Academia
  - SMEs
- Nokia is overall leader
- Ericsson is technical manager

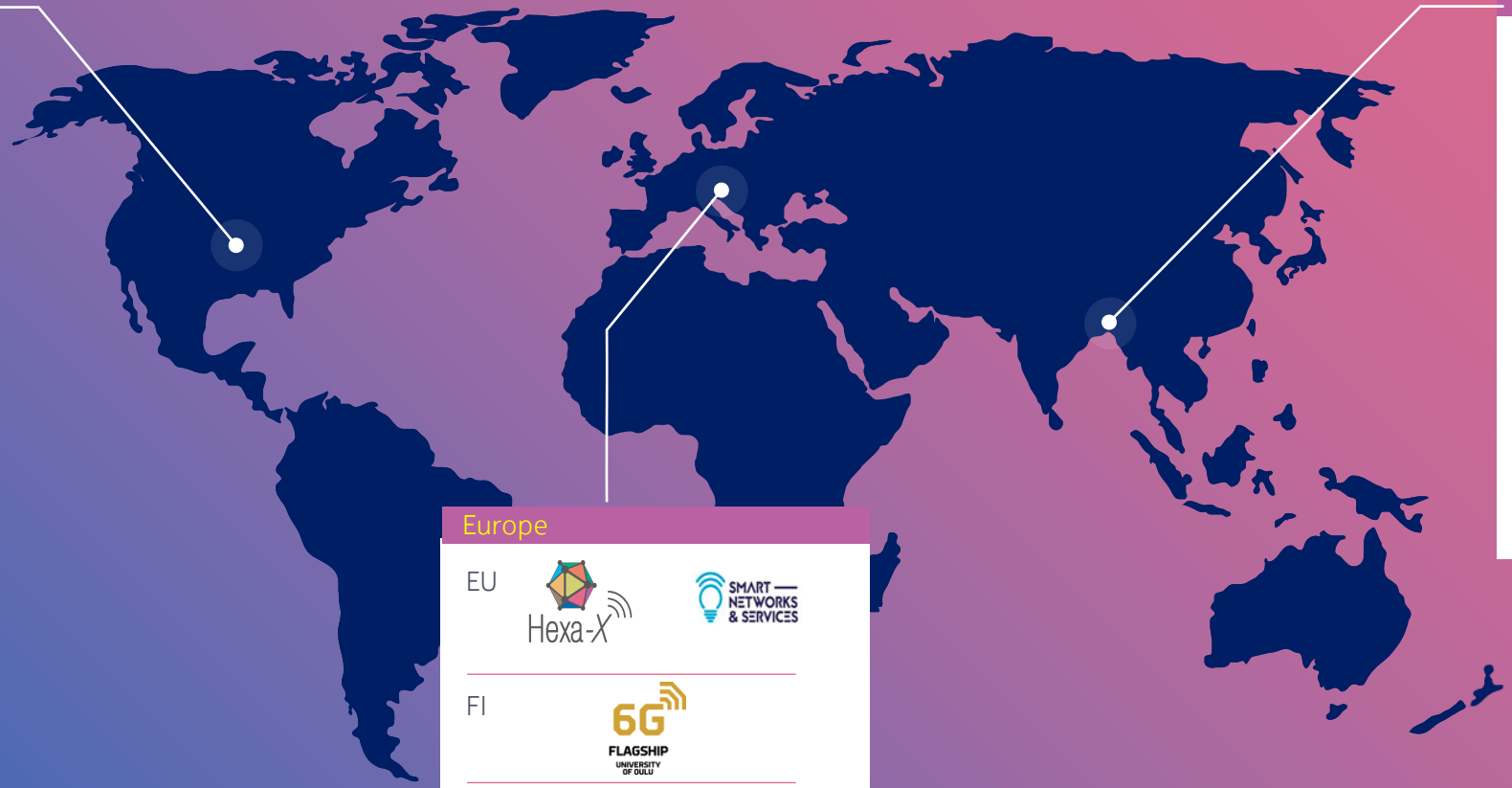


Timeline


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
6G structuring and framing
6G systematisation research projects
6G technical standardisation
6G evolution
Research on 6G technology components
6G requirements
6G commercialisation

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

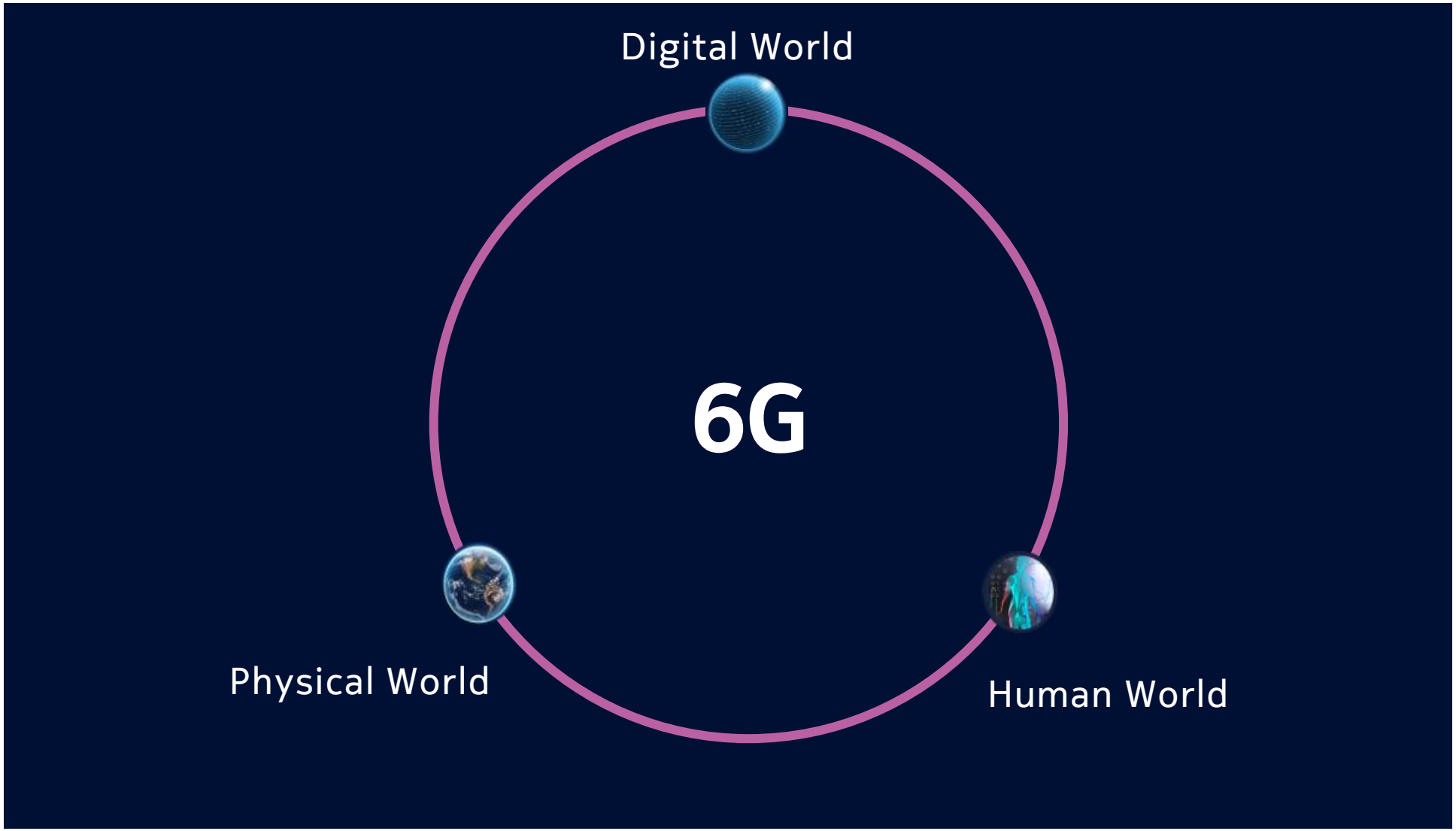
MIC Ministry of Internal Affairs and Communications

IOWN GLOBAL FORUM

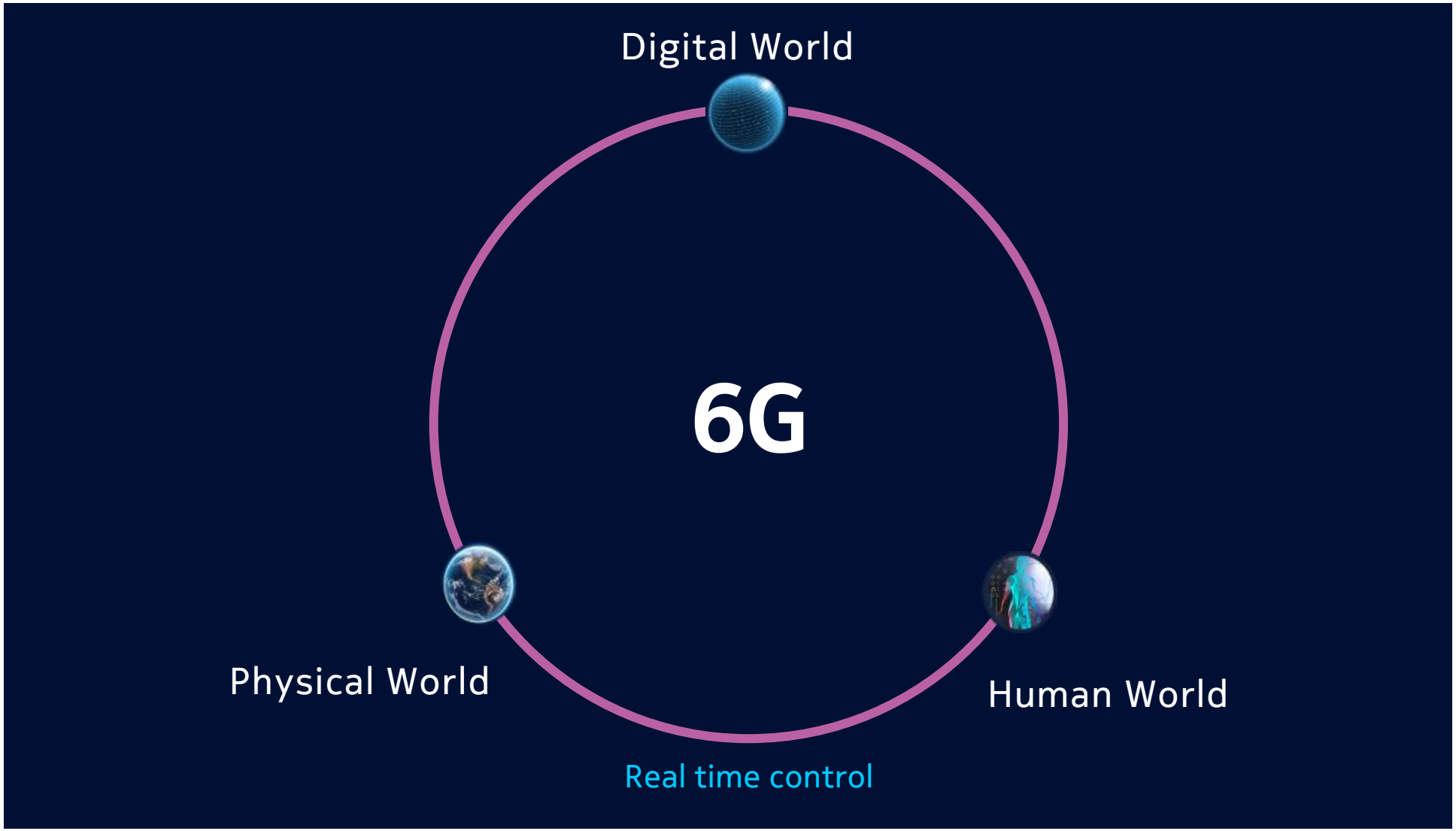
IN

tsdsi

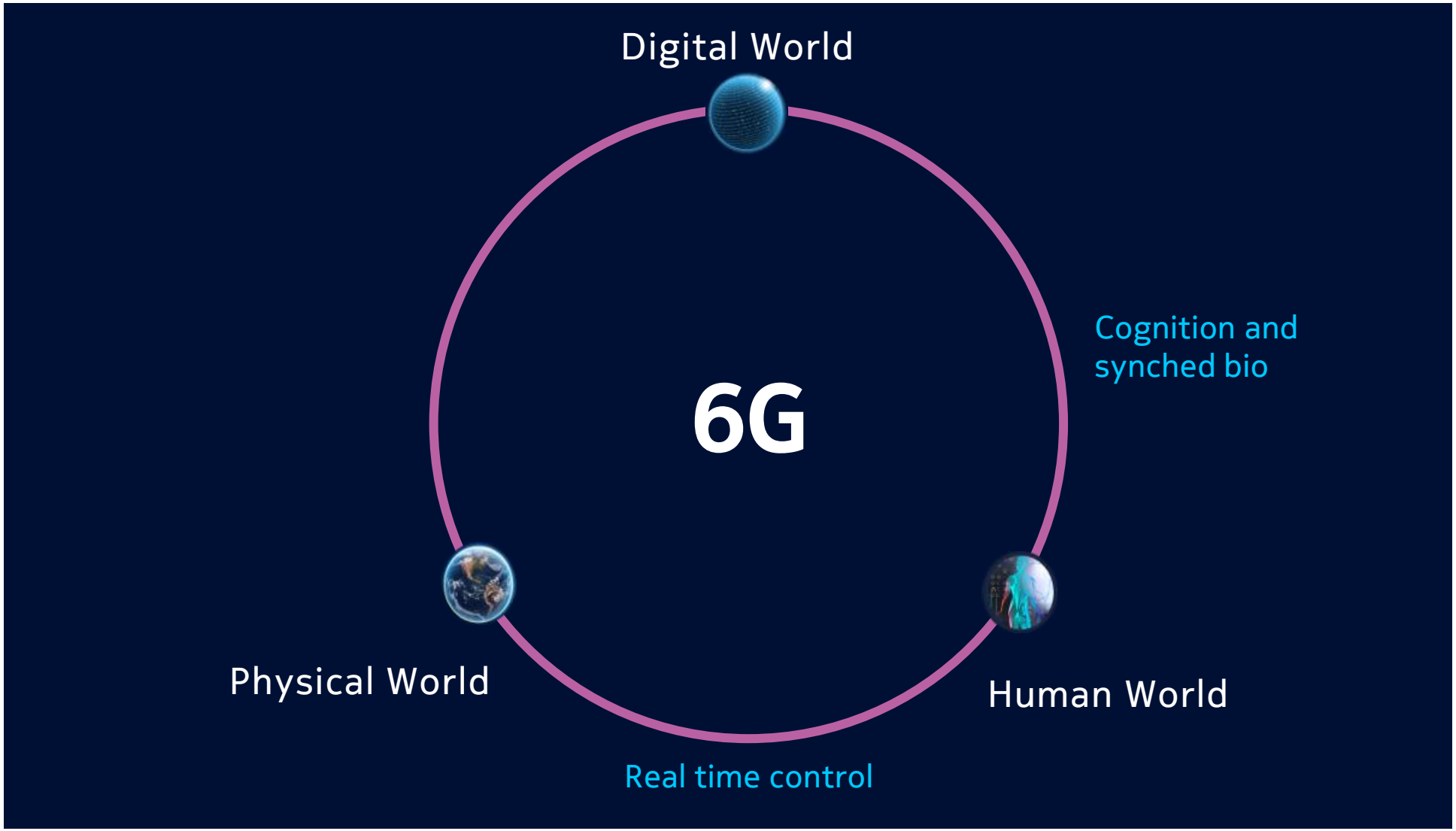
Hexa-X Vision



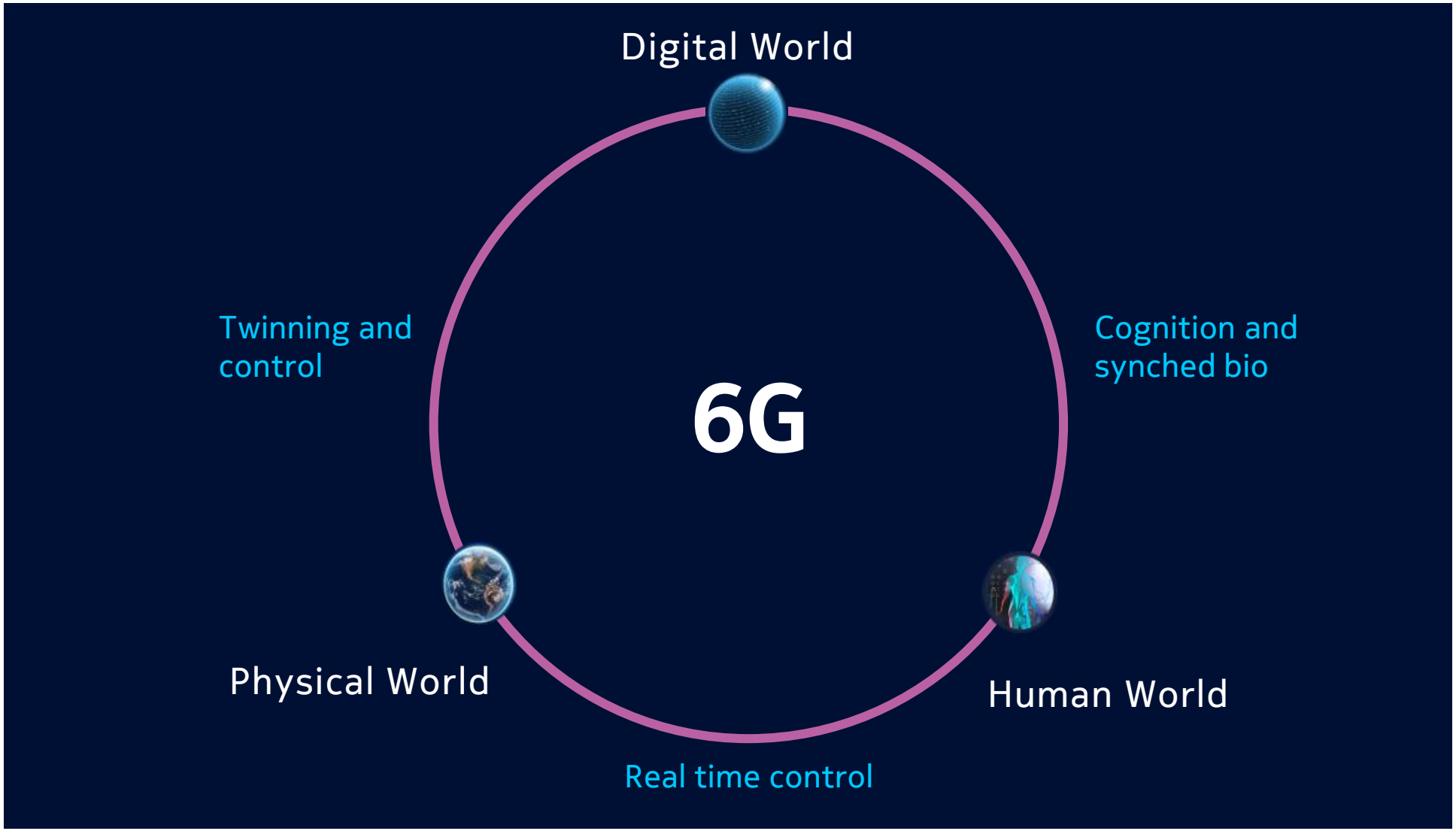
Hexa-X Vision



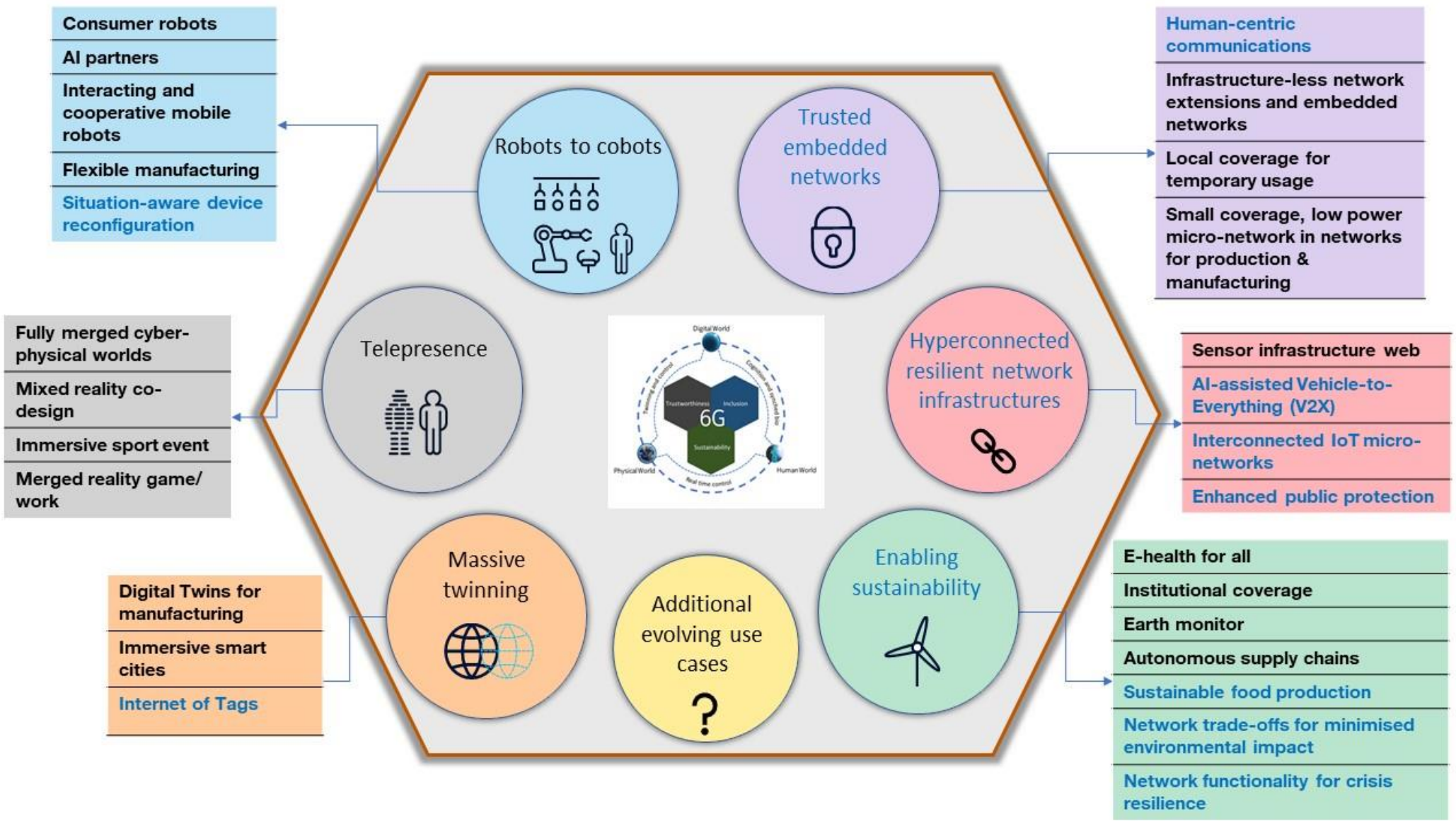
Hexa-X Vision



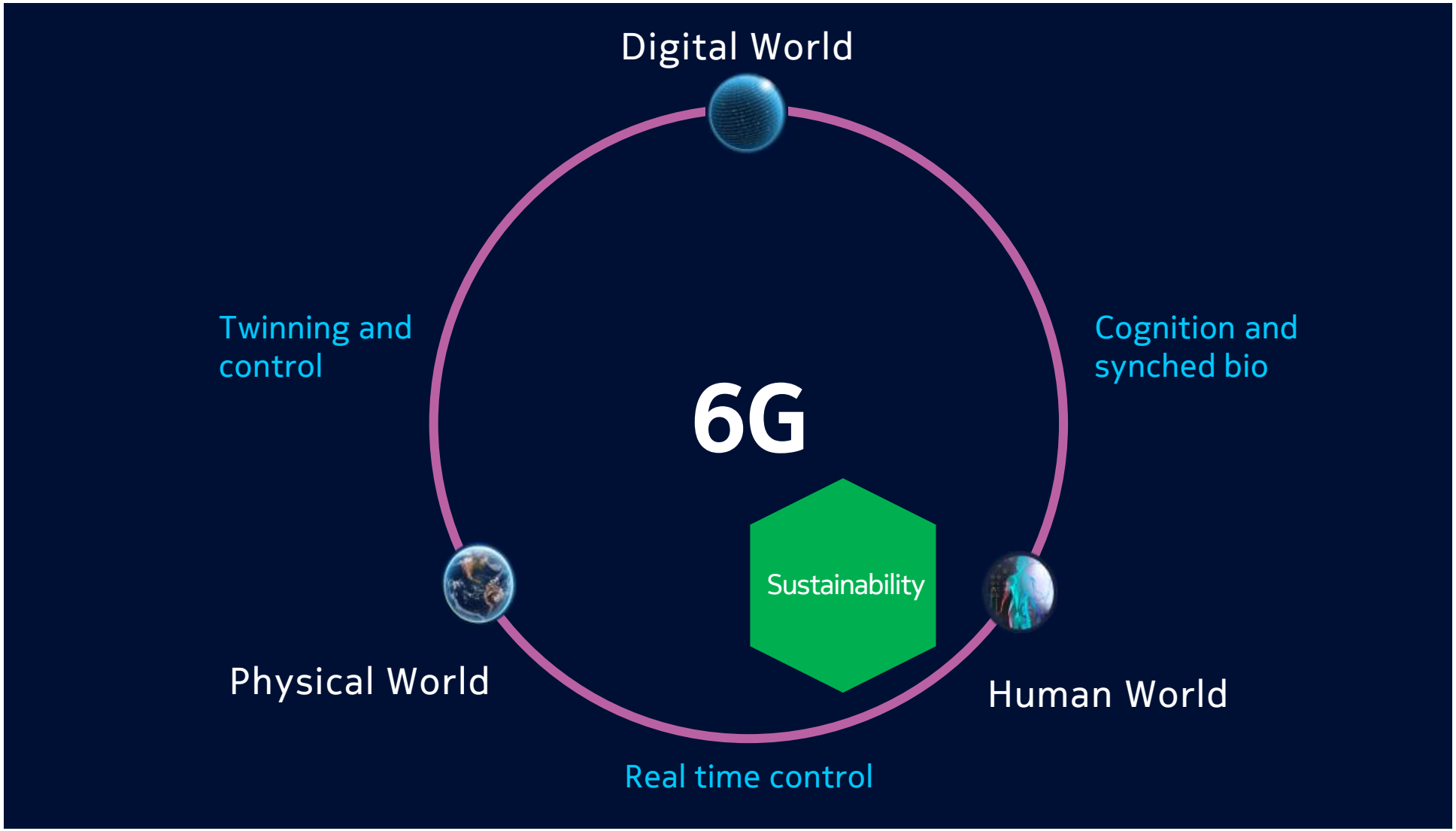
Hexa-X Vision



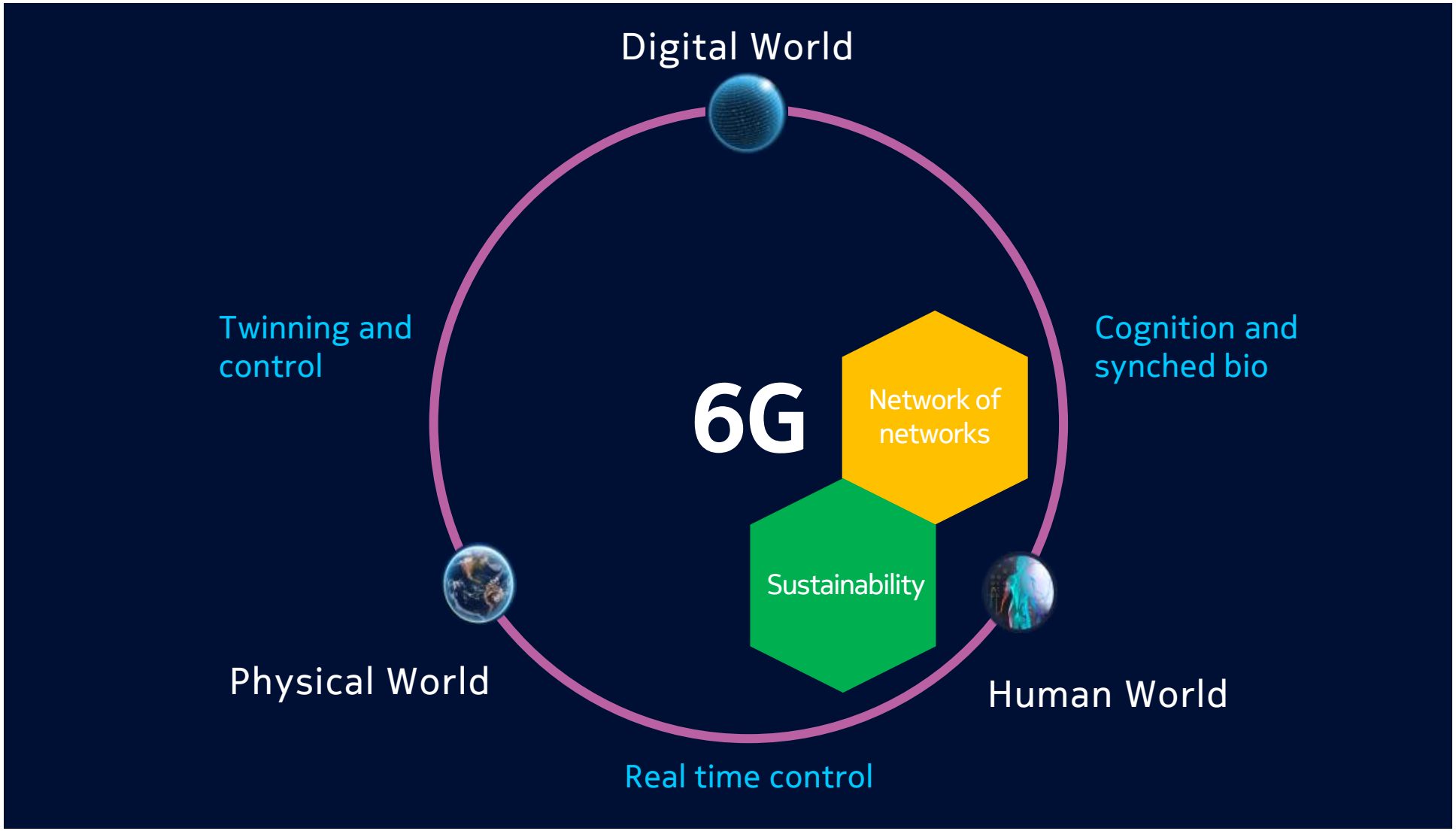
Services and Use cases: 28 use cases, clustered in to 6 families



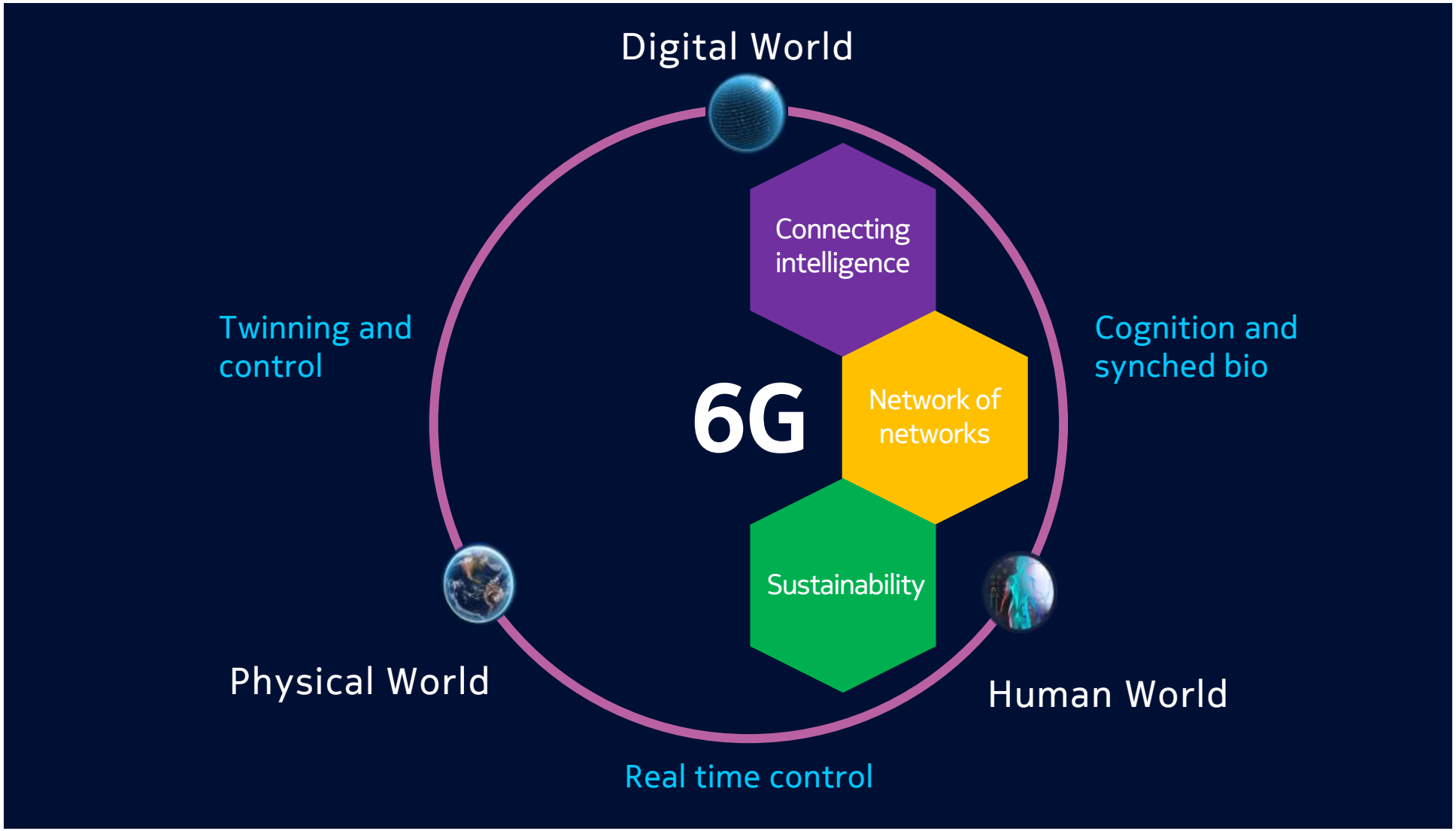
Hexa-X Research Challenges



Hexa-X Research Challenges



Hexa-X Research Challenges



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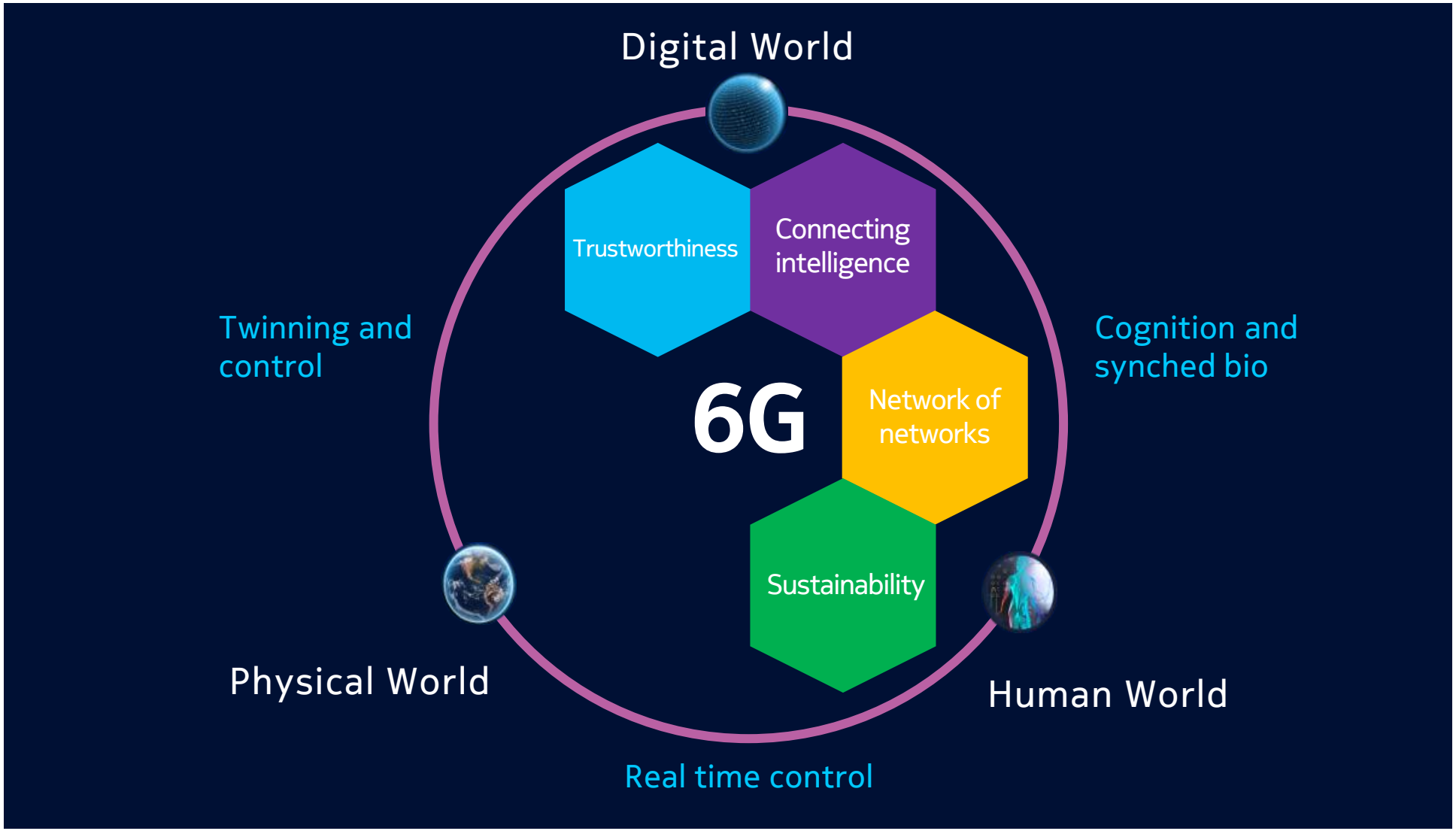

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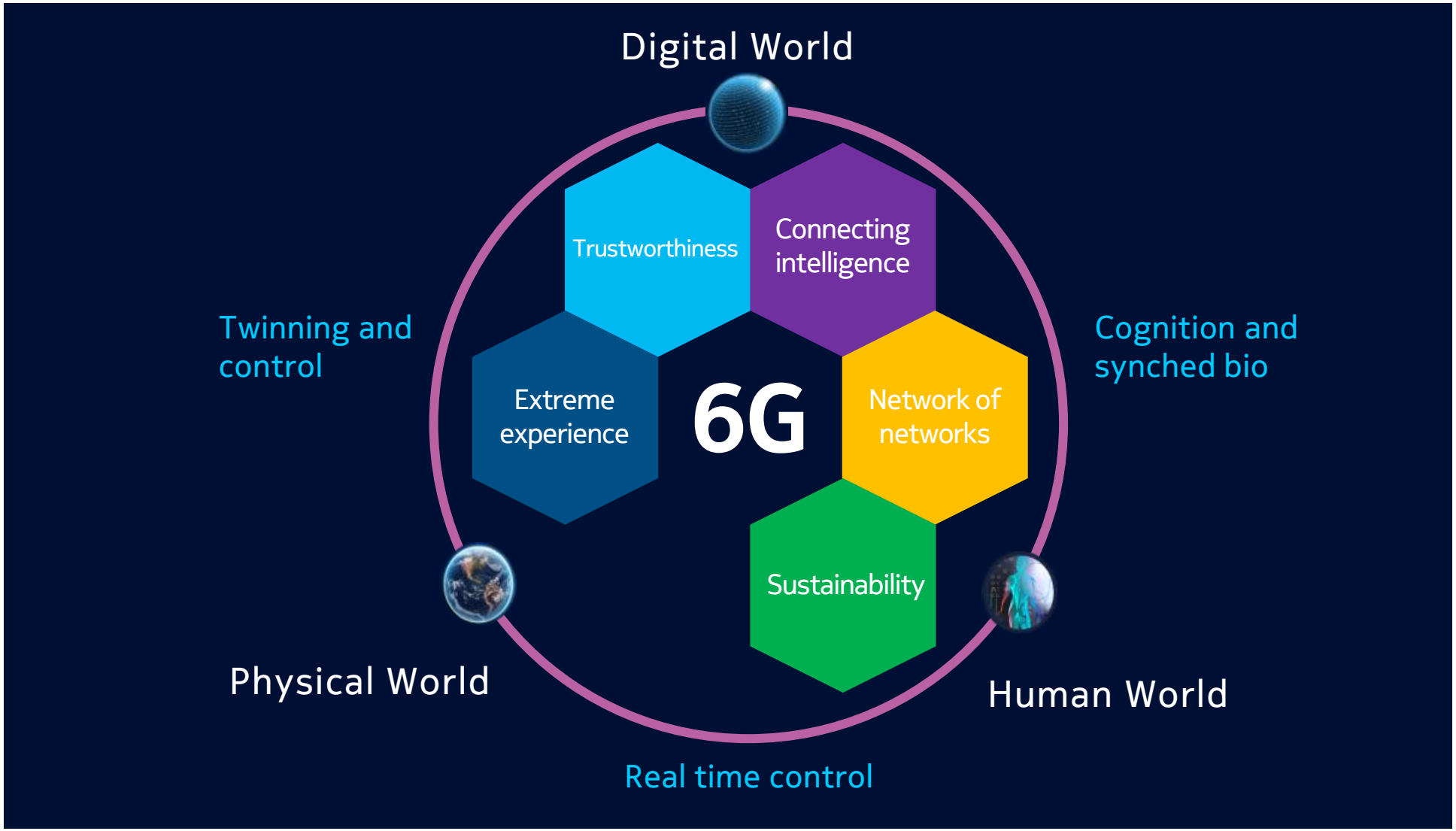

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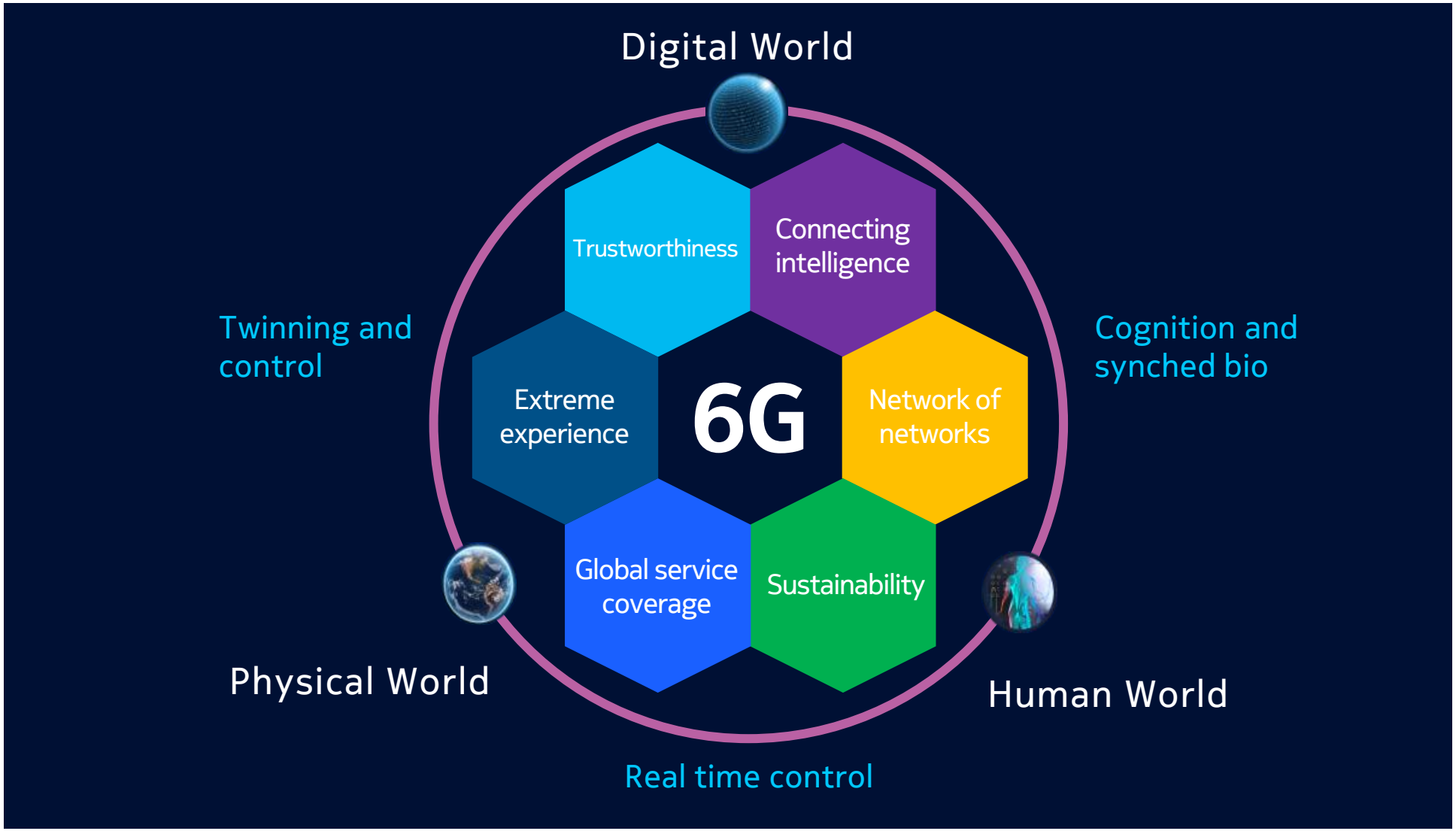
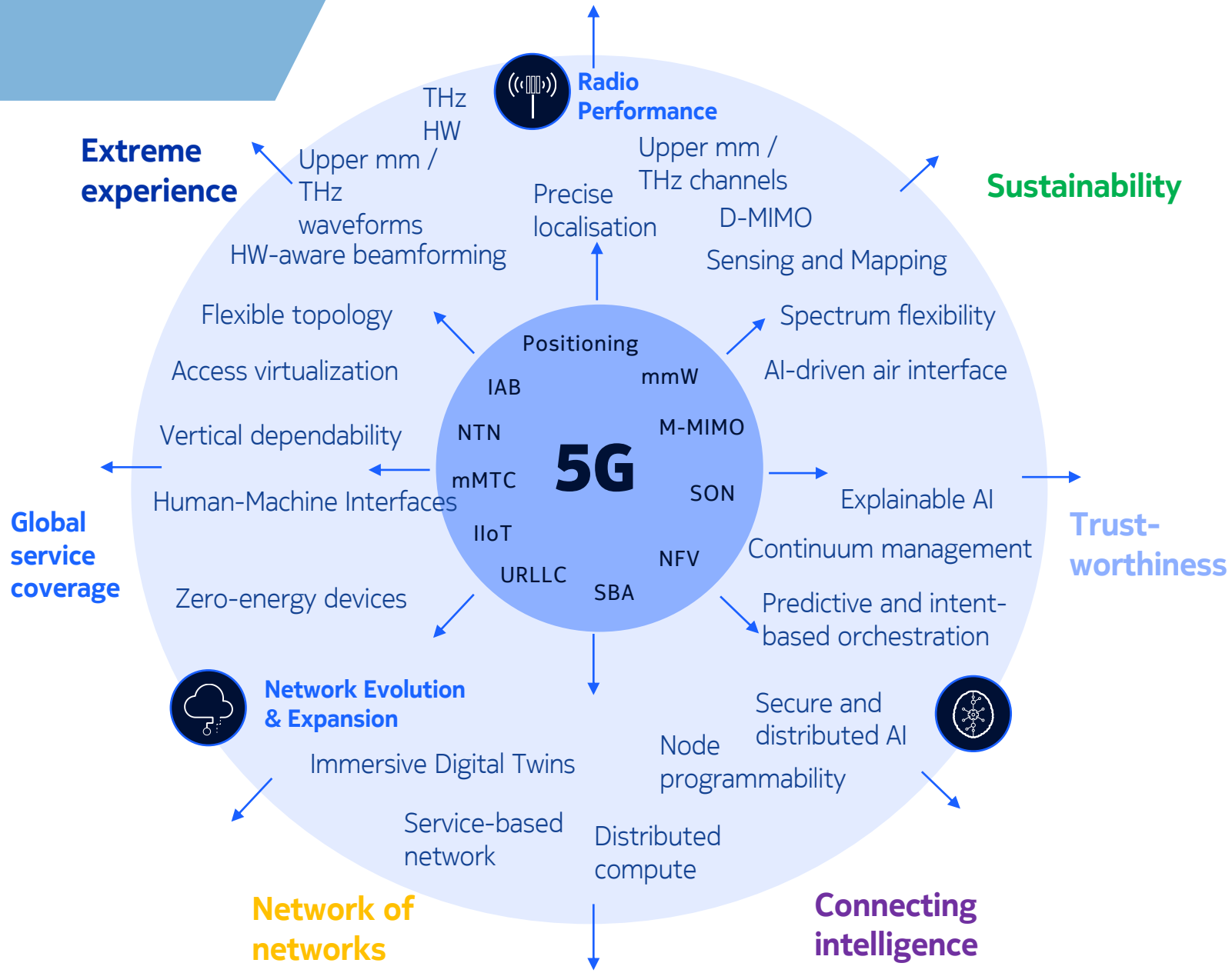
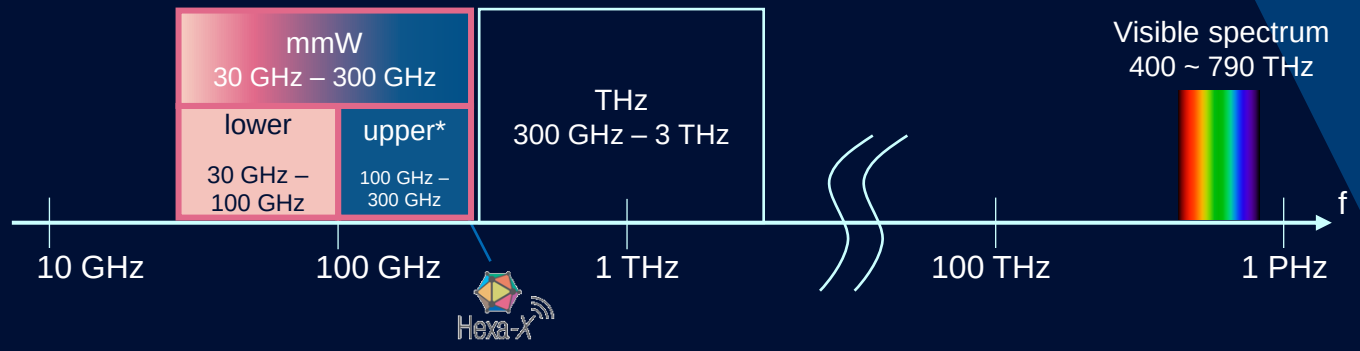


Ambitions


Radio Performance
THz HW
Upper mm / THz waveforms
HW-aware beamforming
Extreme experience
Upper mm / THz channels
Precise localisation
D-MIMO
Sensing and Mapping
Sustainability
Flexible topology
Spectrum flexibility
Access virtualization
AI-driven air interface
Positioning
IAB
mmW
NTN
M-MIMO
5G
mMTC
SON
IIoT
NFV
URLLC
SBA
Vertical dependability
Human-Machine Interfaces
Explainable AI
Continuum management
Predictive and intent-based orchestration
Global service coverage
Trust-worthiness
Zero-energy devices
Network Evolution & Expansion
Secure and distributed AI
Node programmability
Immersive Digital Twins
Service-based network
Distributed compute
Network of networks
Connecting intelligence

Addressing extreme performance

- For Radio research Hexa-X focuses resources on upper mmW (100-300 GHz)
- Lower bands will be essential for coverage but may reuse 5G NR PHY
- Rest of project are mostly frequency-agnostic – solutions should be valid for all ranges (0-300 GHz)

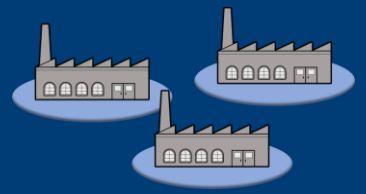


*upper mmW is sometimes known as: “THz” or “sub-THz”. In Hexa-X the preferred term is upper mmW

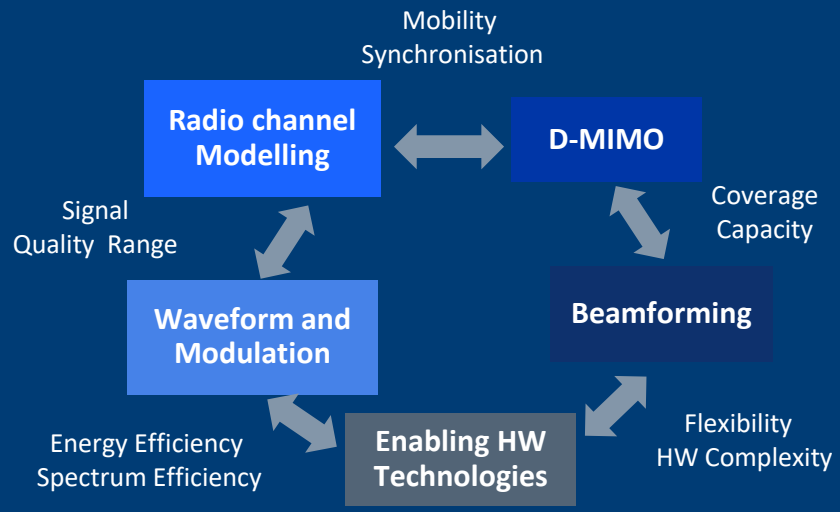
Co-existence with legacy technology

Smooth migration to 6G capabilities

Local spectrum licenses



Enabling new use cases



Source D2.1: Hexa-X_D2.1.pdf)

Classification of mmW technology by communications & sensing functions

6G mmW technology
(in upper & lower 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**

Initial Technical Requirements for 6G Radio beyond 5G NR

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.)

Reimagining purpose of radio connection

Joint communication and sensing

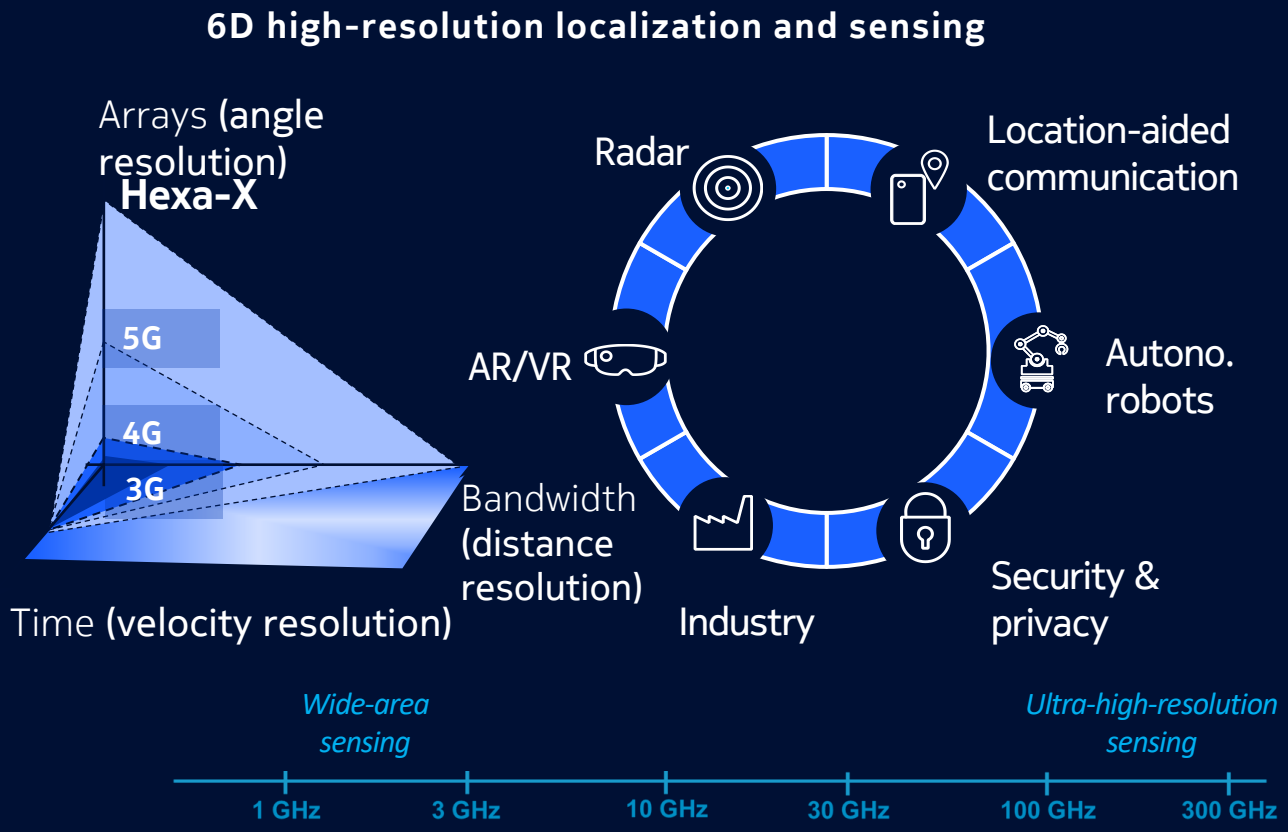
Sensing functionality as an integrated part of the communication network

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

To enable new and enhanced services

To enhance the network performance

First results will be available end of December

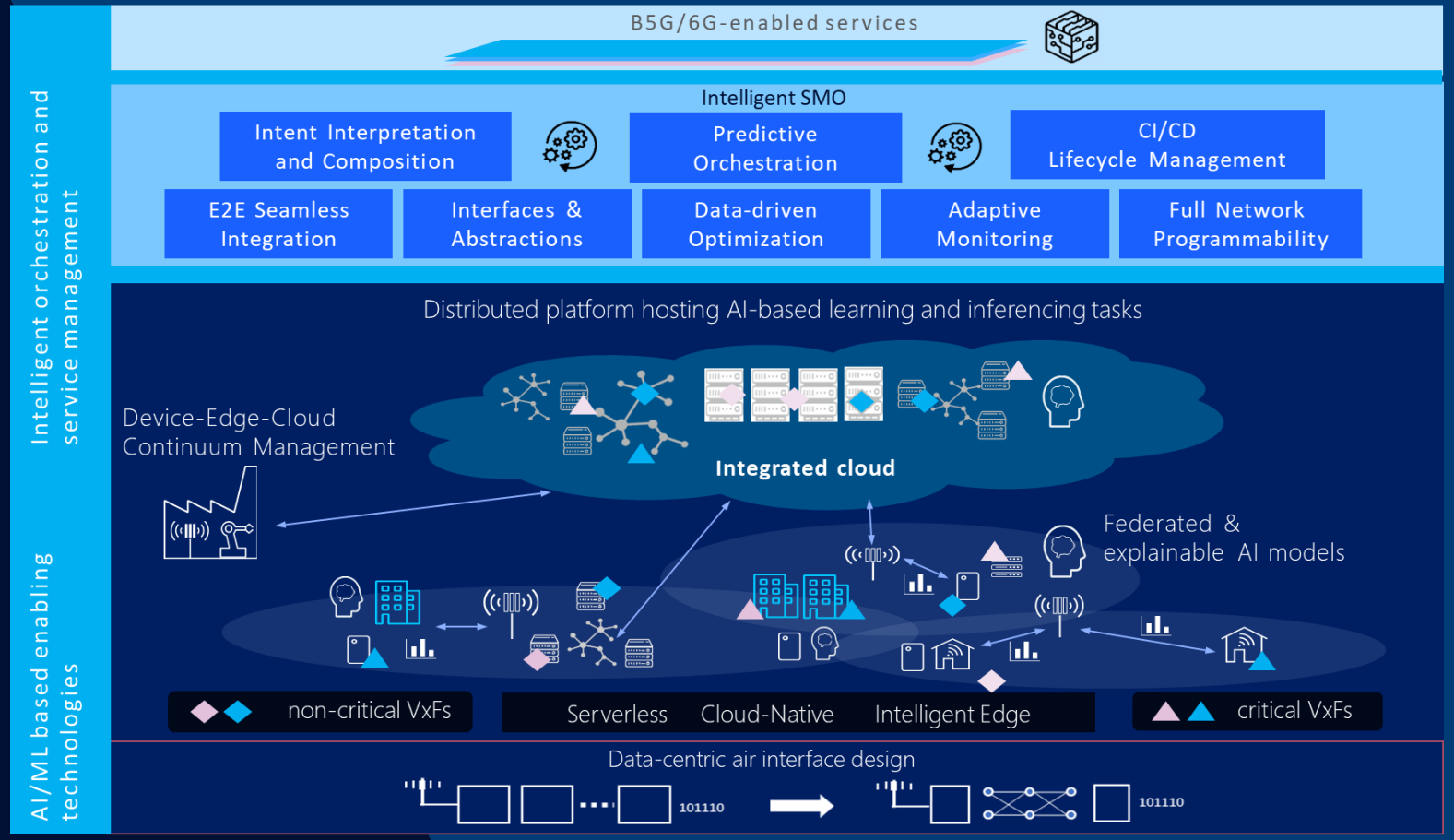


Data-driven operation

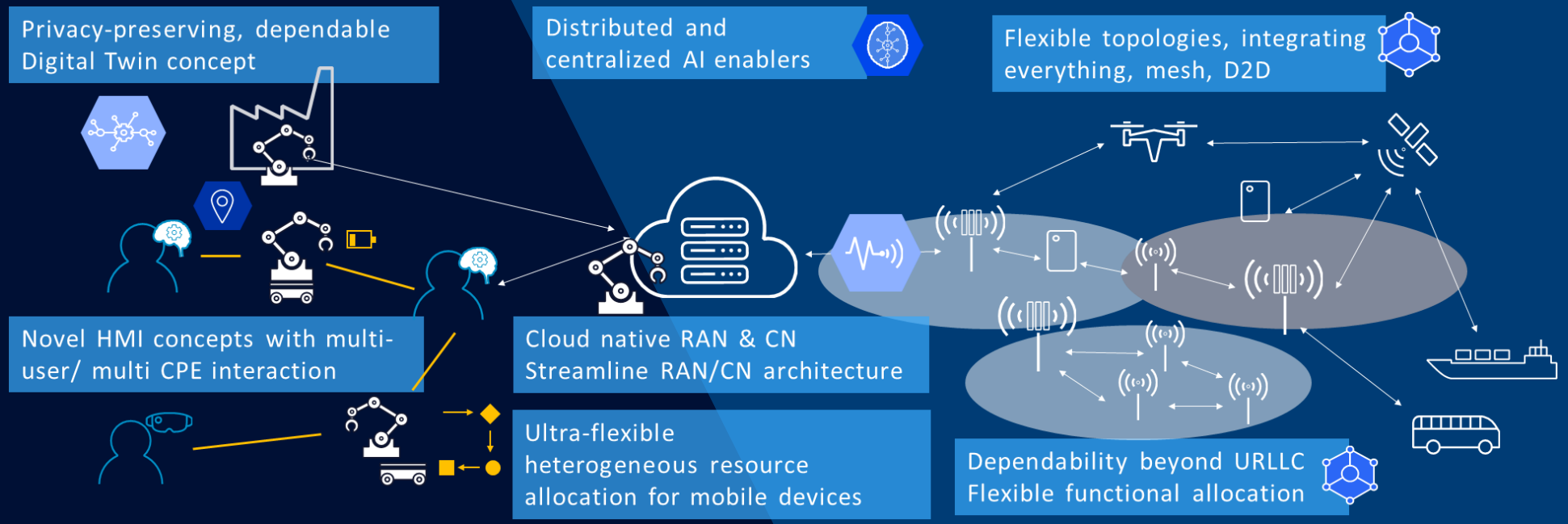
- **Overall trend:**
  - More and more AI
- **Why this trend? AI can help to:**

  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



Network evolution and expansion towards 6G



Flexible and dynamic networks

Integration of new types of access nodes and devices

Versatile programmable transport, devices and network for cost effective densification and faster TTM

Dynamically deployable AI/ML agents

Addressing needs from enterprises and verticals

Network architecture optimized for cloud

Based on a common cloud platform and IT tools

Fully service-based

Having enhanced functional separation

Enabling optimization and simplification

Sustainability

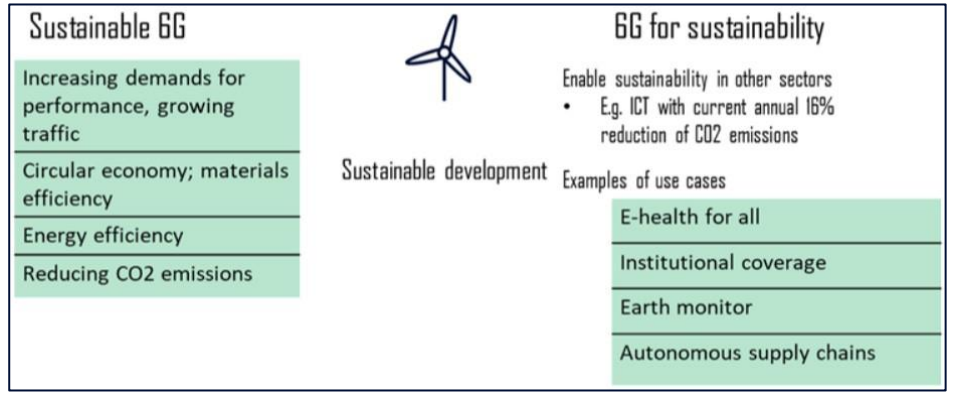
Ambition

ICT is linked to all 17 UN SDGs and interacts with all of them. For instance:
•#9 (Industry, innovation and infrastructure): 6G will contribute to bridging the digital divide to provide equal access to information and foster entrepreneurship, for billions.
•#11 (Sustainable cities and communities): ICT enables innovative approaches to city management (smart water and waste management, intelligent transportation).
•#13 (Climate action): 6G will help monitor climate change and strengthen resilience, and will enable other sectors to reduce their own emissions. At the same time, 6G will have its own carbon footprint which should be minimized

UN Action plan:
17 goals
165 targets
231 indicators

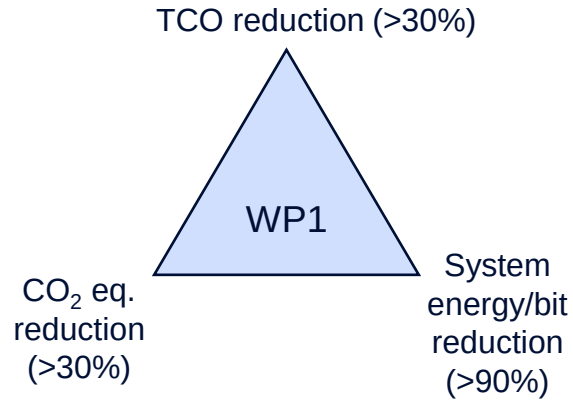
How

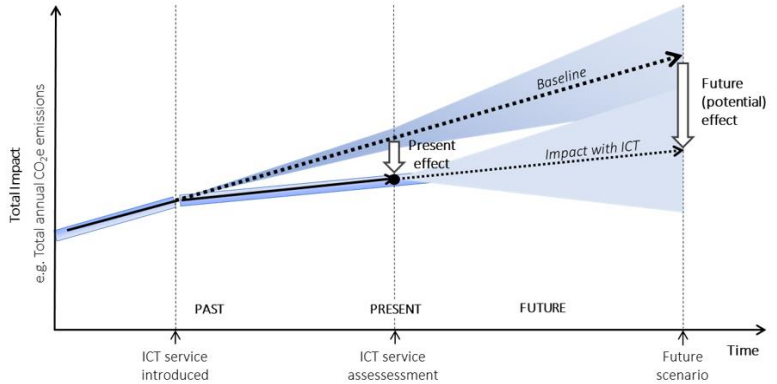
- Embedded energy monitoring systems everywhere.
- Adaptive telecommunication protocols, to avoid the need for 'always-on' infrastructure; push toward Zero watt @ zero load for all products.
- Systematic assessment of environmental impact of materials and design choices, including virtualization and softwarization (e.g. balance between latency and energy).
- Equipment and consumer products eco-design: modularity, upgradeability, reparability.
- Limiting obsolescence: circularity, refurbishment, effective management of end-of-life.
- New energy efficient material (e.g. GaN for sub 3 GHz products).
- Continue the development of energy efficiency features and compact and efficient renewable energy supply solutions.
- Big potential using AI for green networks (overdimensioning...)
- EMF-aware networks.



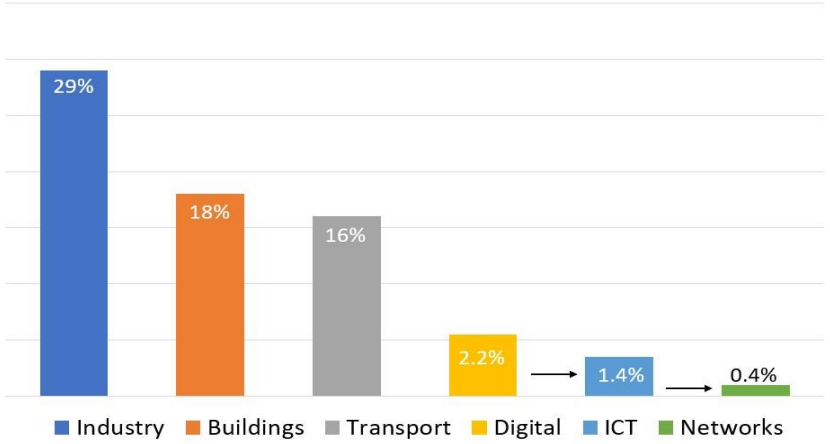
Sustainability targets

- Global KPI for sustainability has been defined in accordance with Hexa-X project objective:
  - KPI1: Enabling reduction of emission of more than 30% Co2 in a sector using 6G as an enabler.
  - KPI2: More than 30% reduction for the Total Cost Ownership (TCO) including energy fees.
  - KPI3: More than 90% energy consumption reduction per energy/bit.
- For each KPI, a baseline, methods to achieve the target and the scope of the KPI have been defined.
- Methods include
  - Life cycle analysis of products and systems for all KPIs
  - Methodology for evaluating the "Enablement effect" for KPI1
  - Networks environmental impact and trends for KPI2 and KPI3





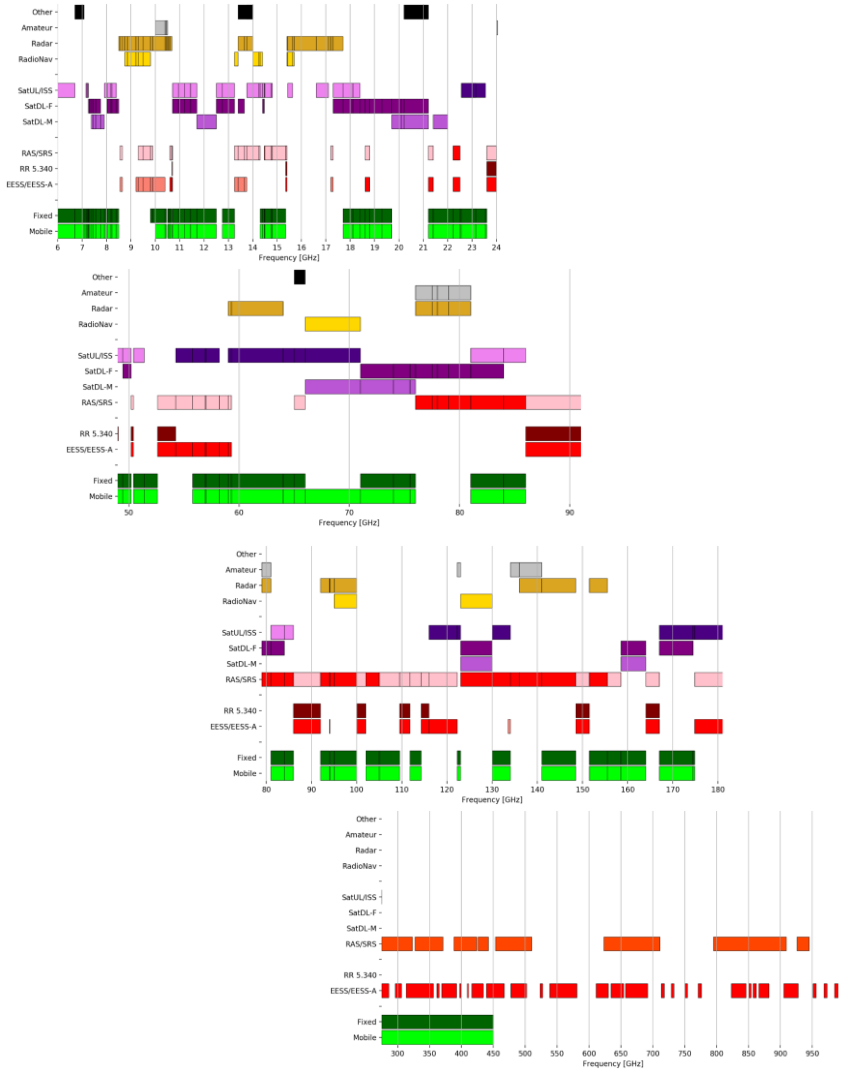
Share of the global GHG emissions by sector
(first three columns not to scale)



Spectrum evolution aspects

Improve spectrum utilization & extend current spectrum boundaries

- 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 radio coverages
- Possible usage of spectrum in 6-24 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
- Studies on intelligent spectrum usage and interference management schemes will include scenarios for, e.g.,
  - nomadic, mobile, or temporary spectrum usage
  - spectrum access for local low power networking
  - exploitation of predictable properties of radio transmissions for AI-based interference avoidance
- New regulation and licensing strategies aspects in support of both dynamic spectrum sharing and access to new spectrum will be comprehensively addressed



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

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
  - D3.1 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
  - D6.1 Gaps, features and enablers for B5G/6G service management and orchestration
  - D7.1 Gap analysis and technical work plan for special-purpose functionality

- 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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