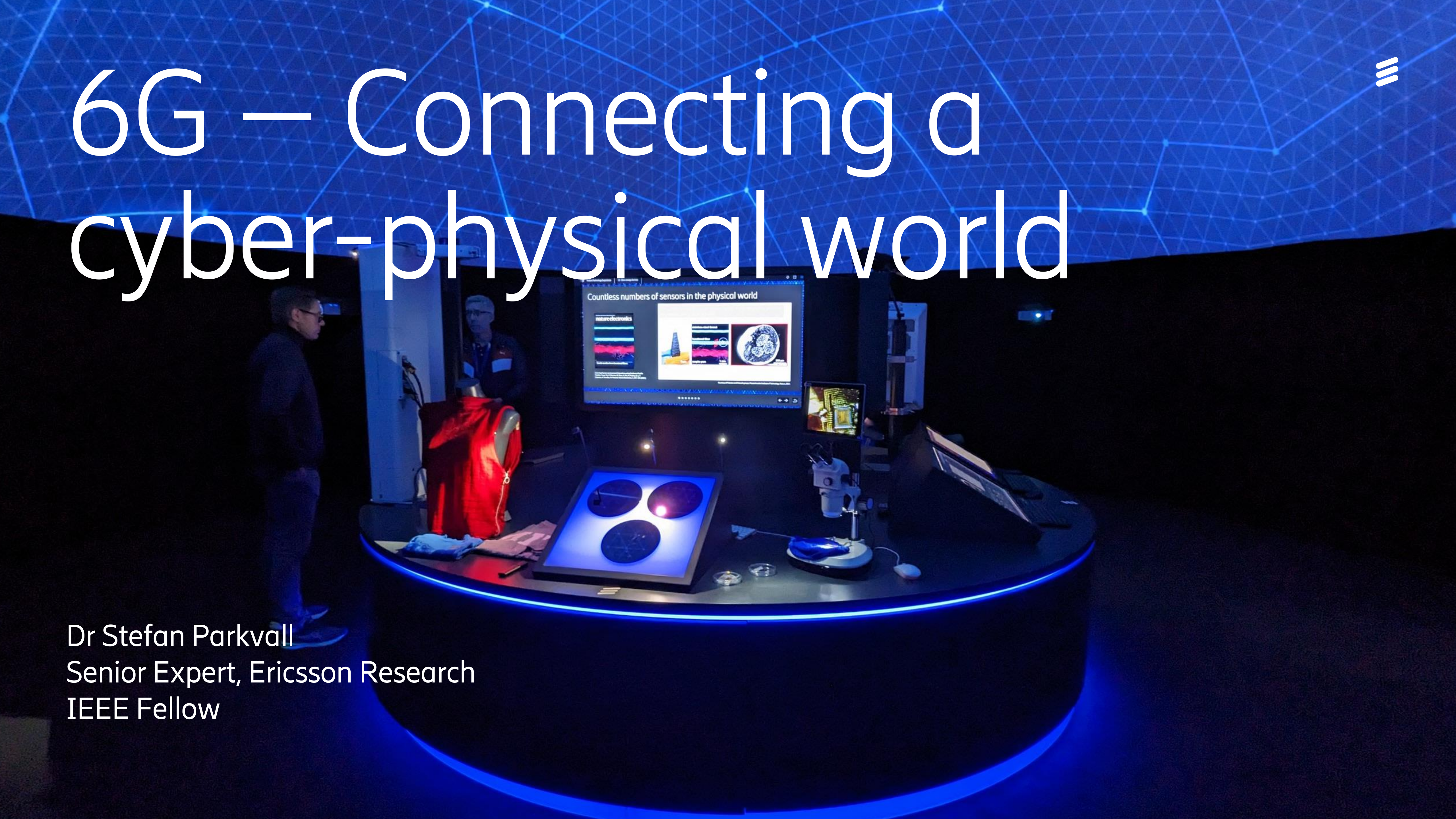
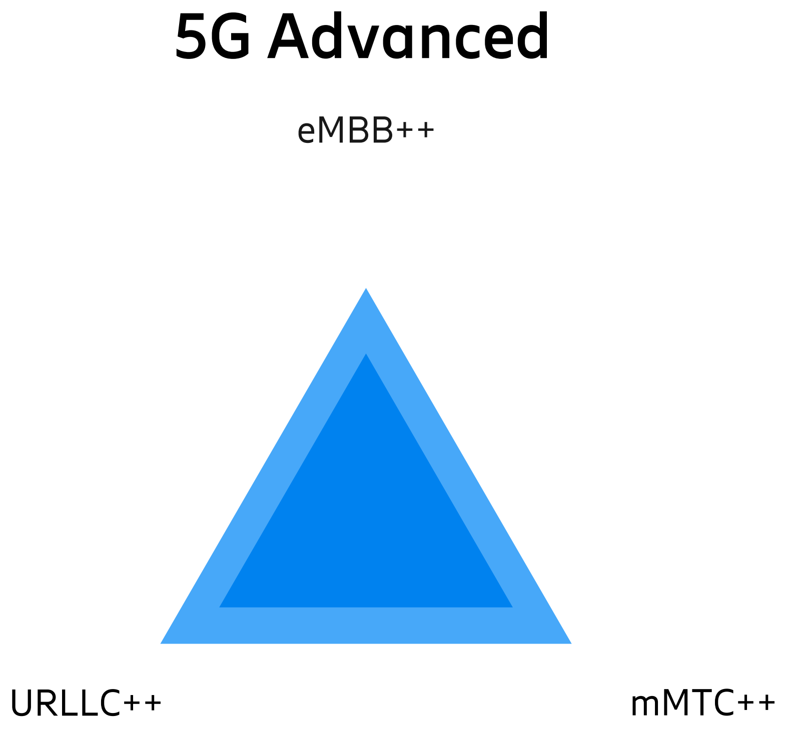
6G — Connecting a cyber-physical world



Dr Stefan Parkvall
Senior Expert, Ericsson Research
IEEE Fellow

6G focus areas



6G focus areas

Communication beyond 5G & Further enhanced MBB

Immersive communication – expanding on eMBB

Critical communication – expanding on URLLC

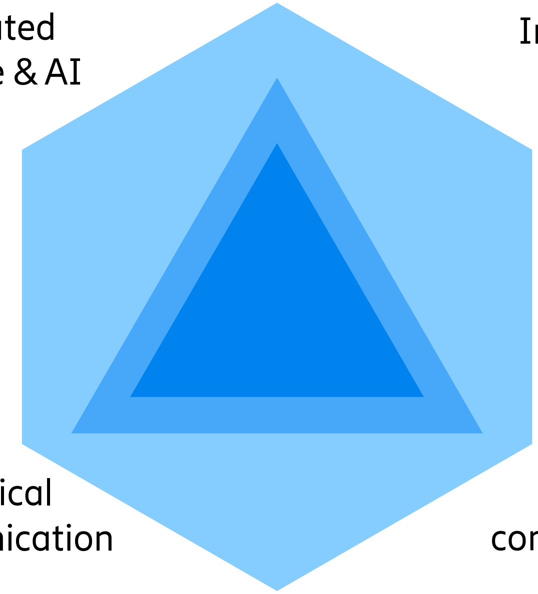
Massive communication – expanding on mMTC

6G

Immersive communication

Integrated Compute & AI

Integrated sensing



Critical communication

Massive communication

Global broadband communication

Beyond-communication networks

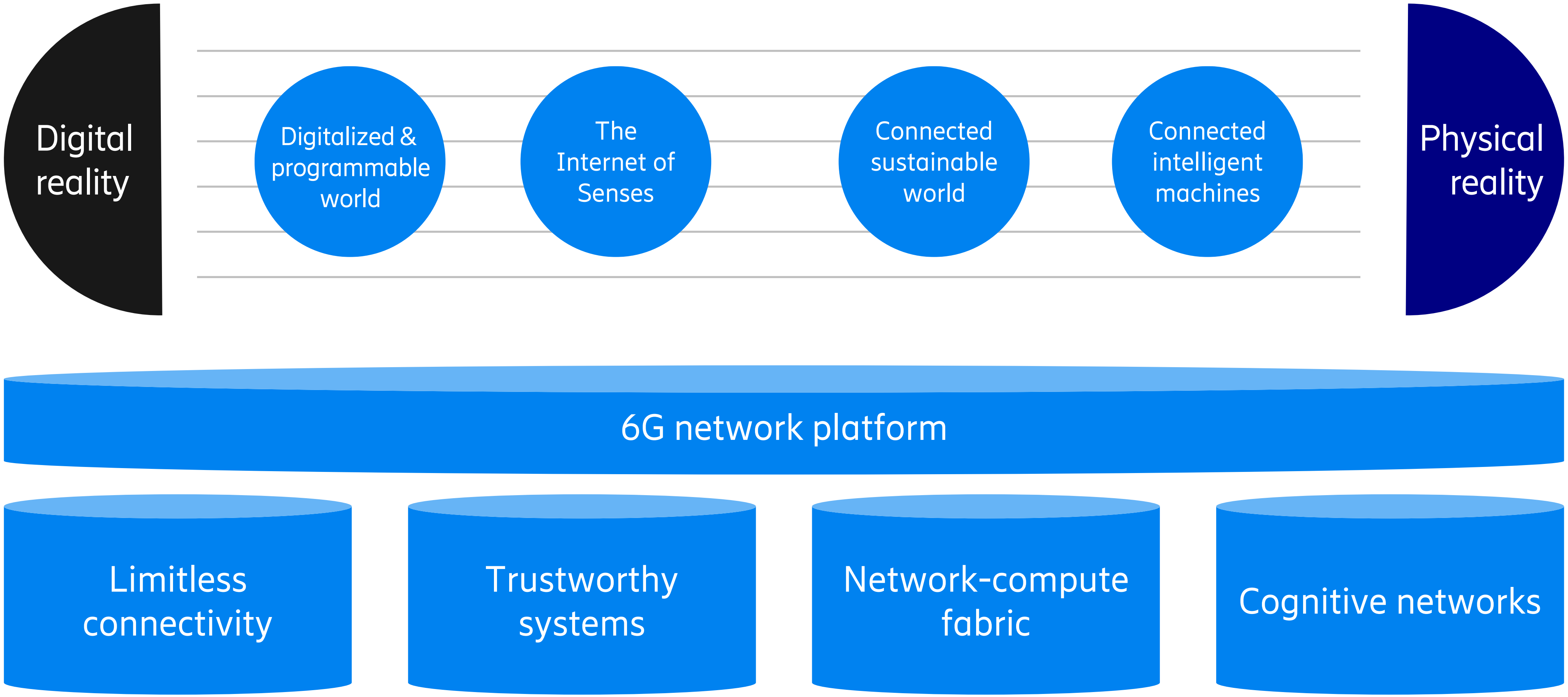
New services on 6G platform

Sustainable and trustworthy networks

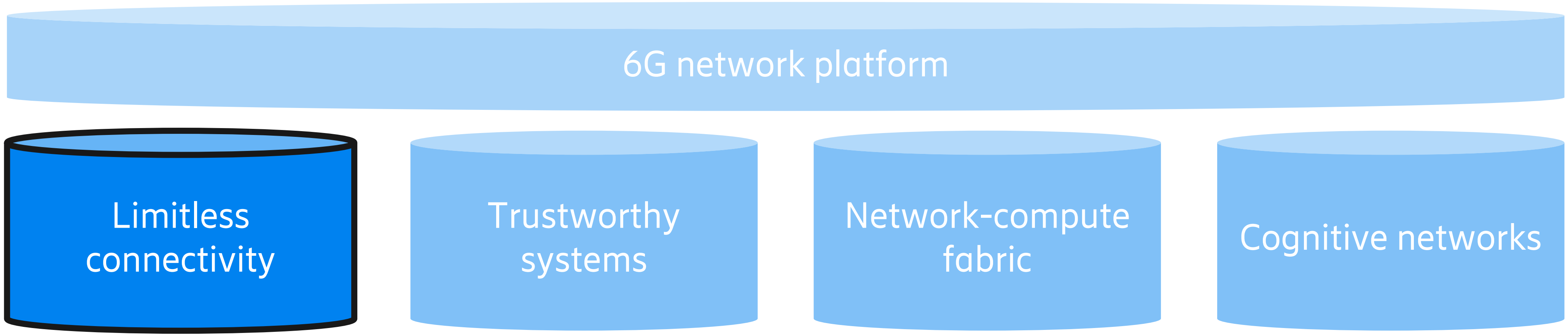
Sustainability and trust imperatives

Connecting a cyber-physical world

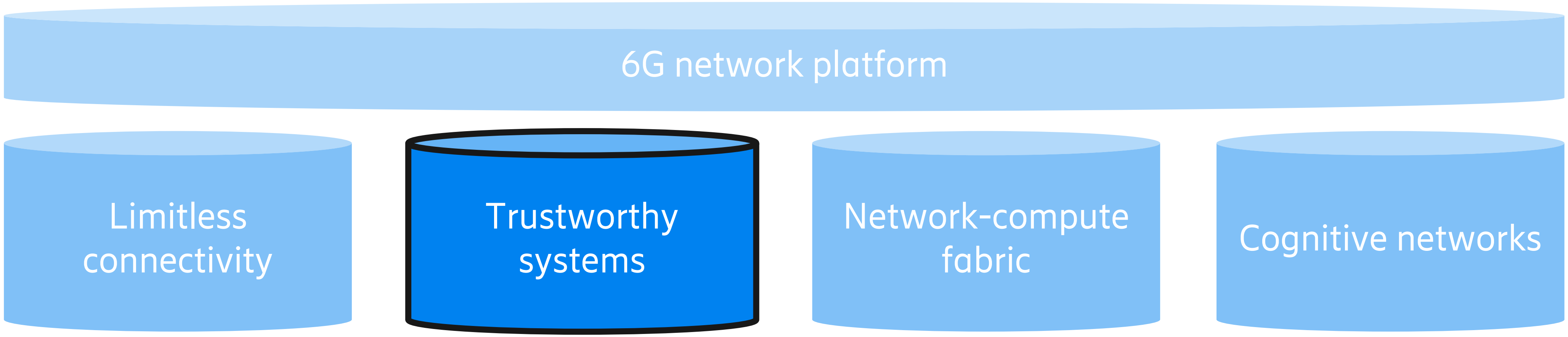
Arriving at the 6G destination – the 6G network platform



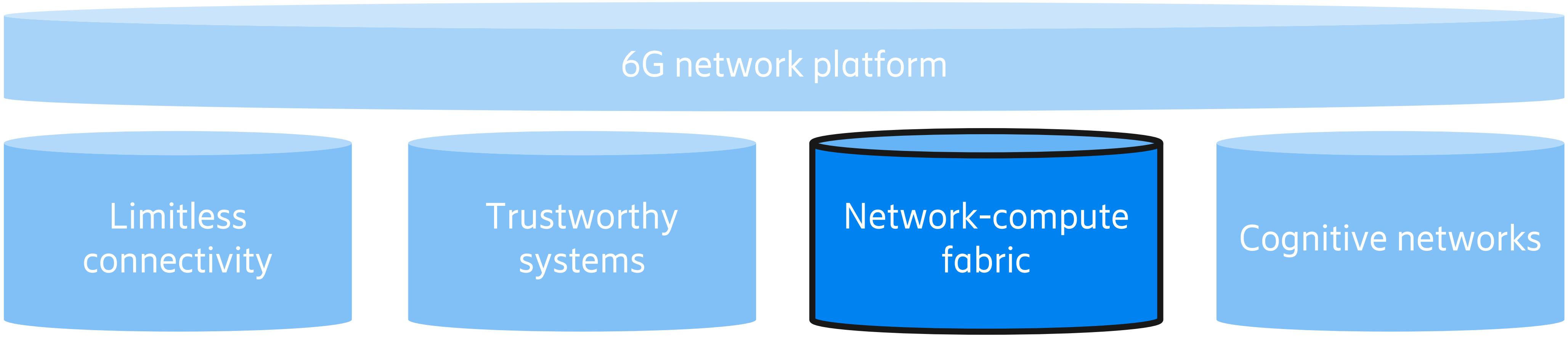
6G network platform



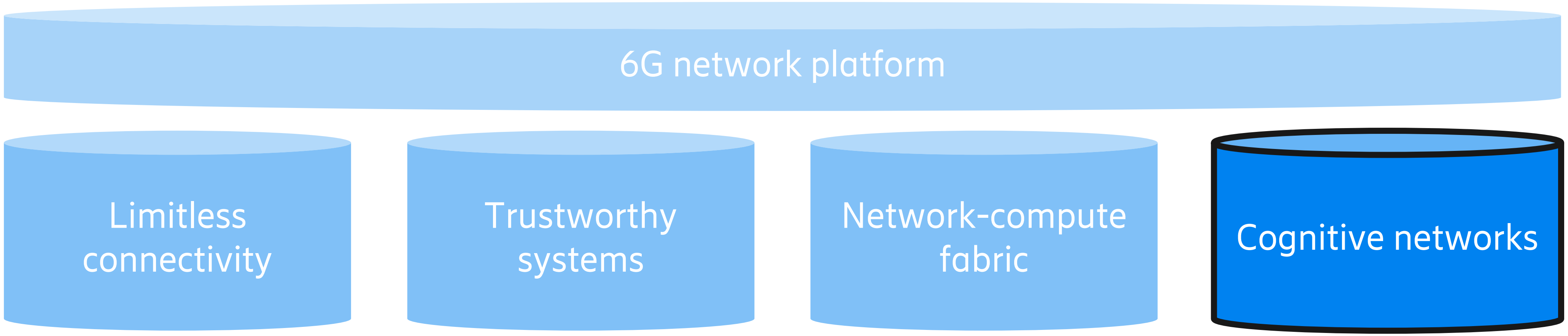
6G network platform



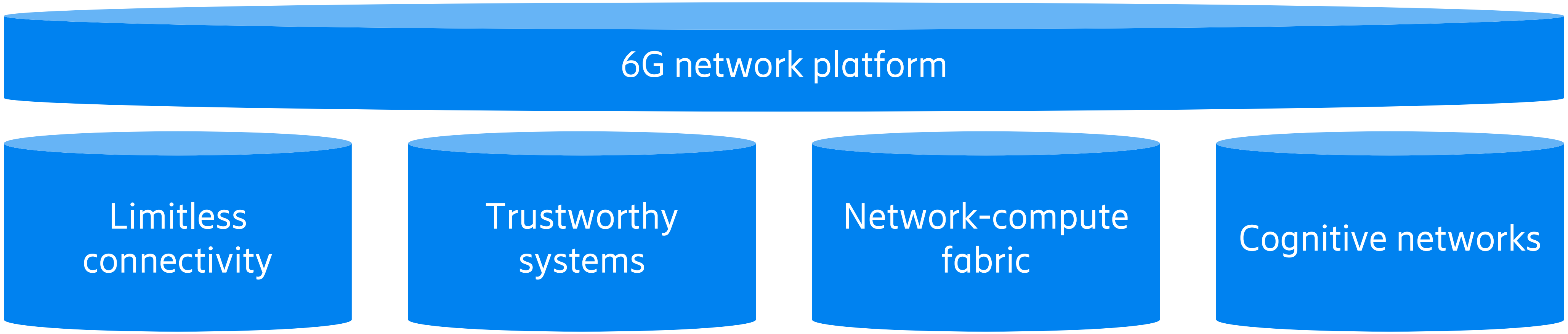
6G network platform



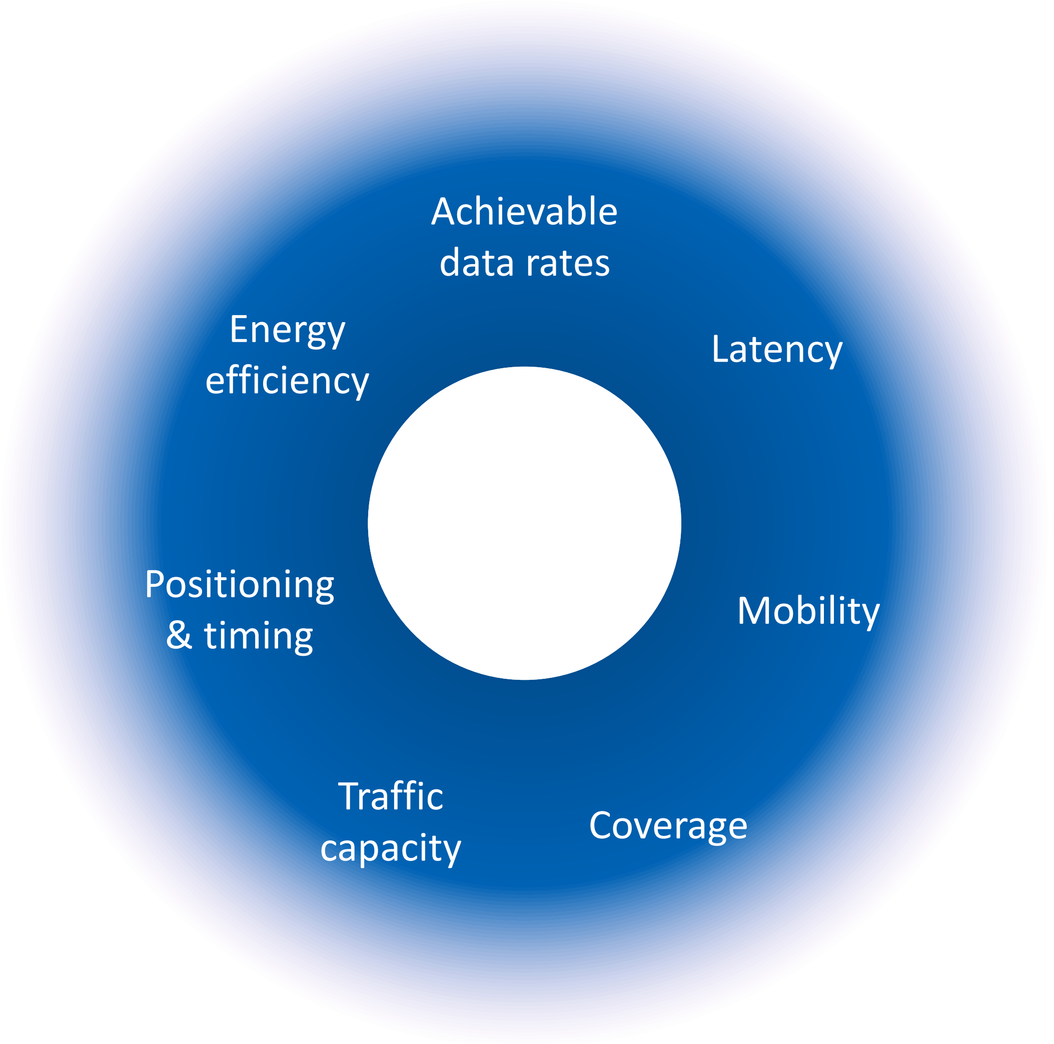
6G network platform



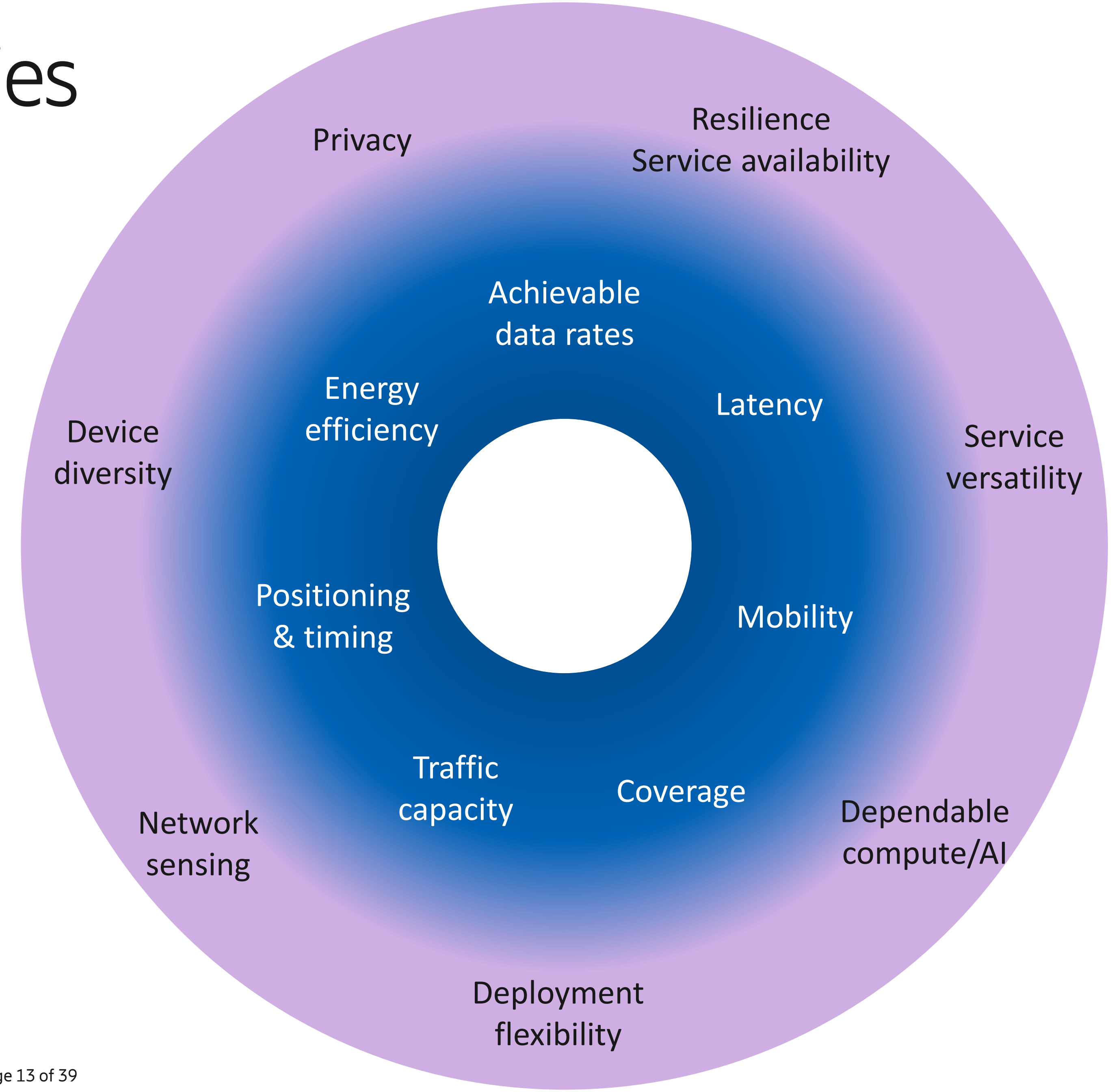
6G network platform



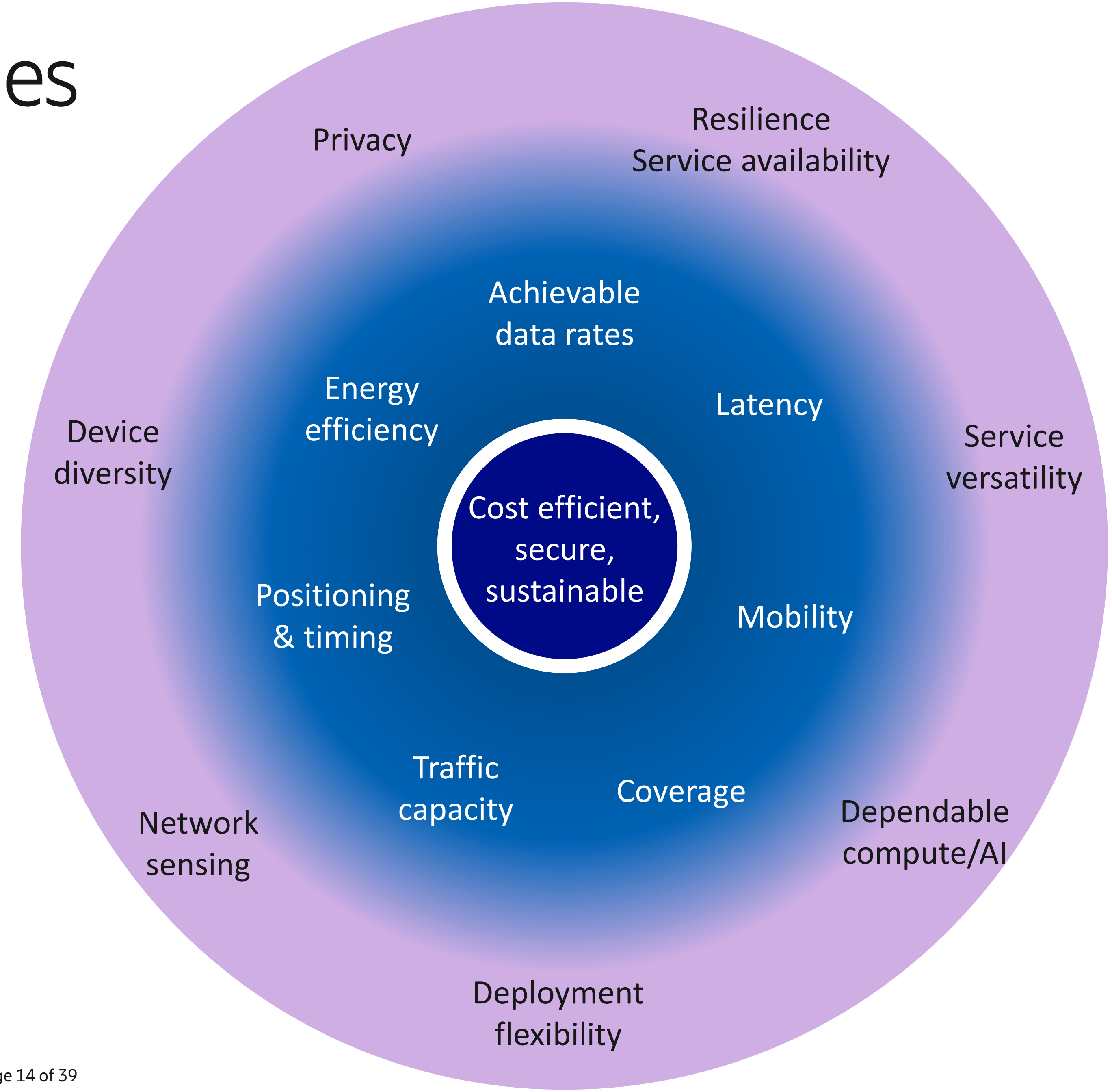
6G capabilities



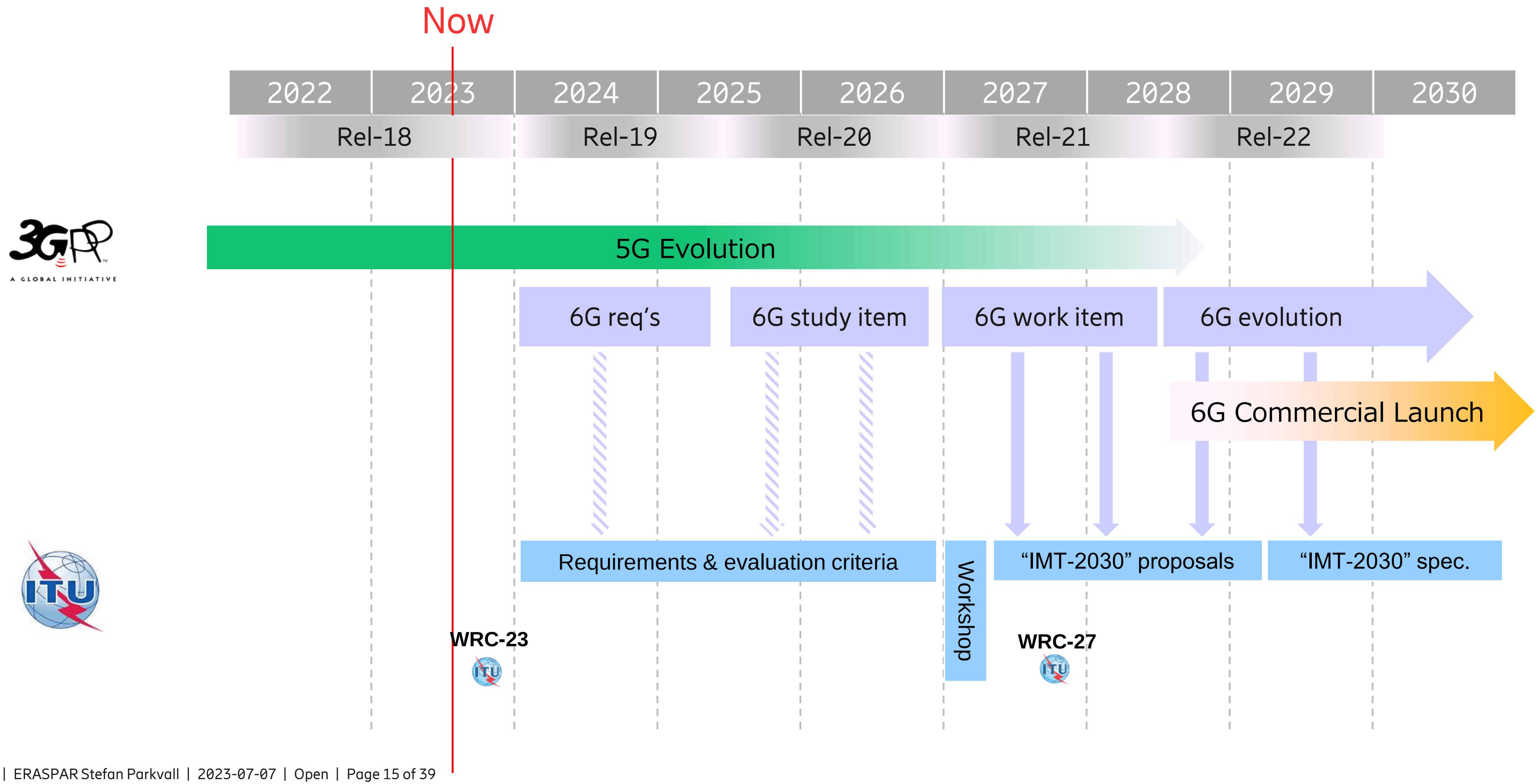
6G capabilities



6G capabilities

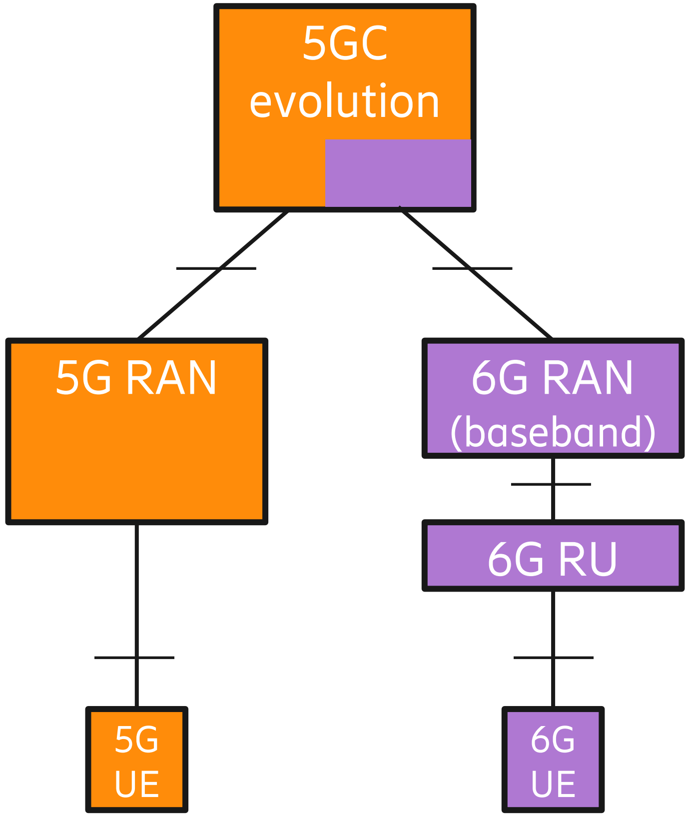


6G timeline

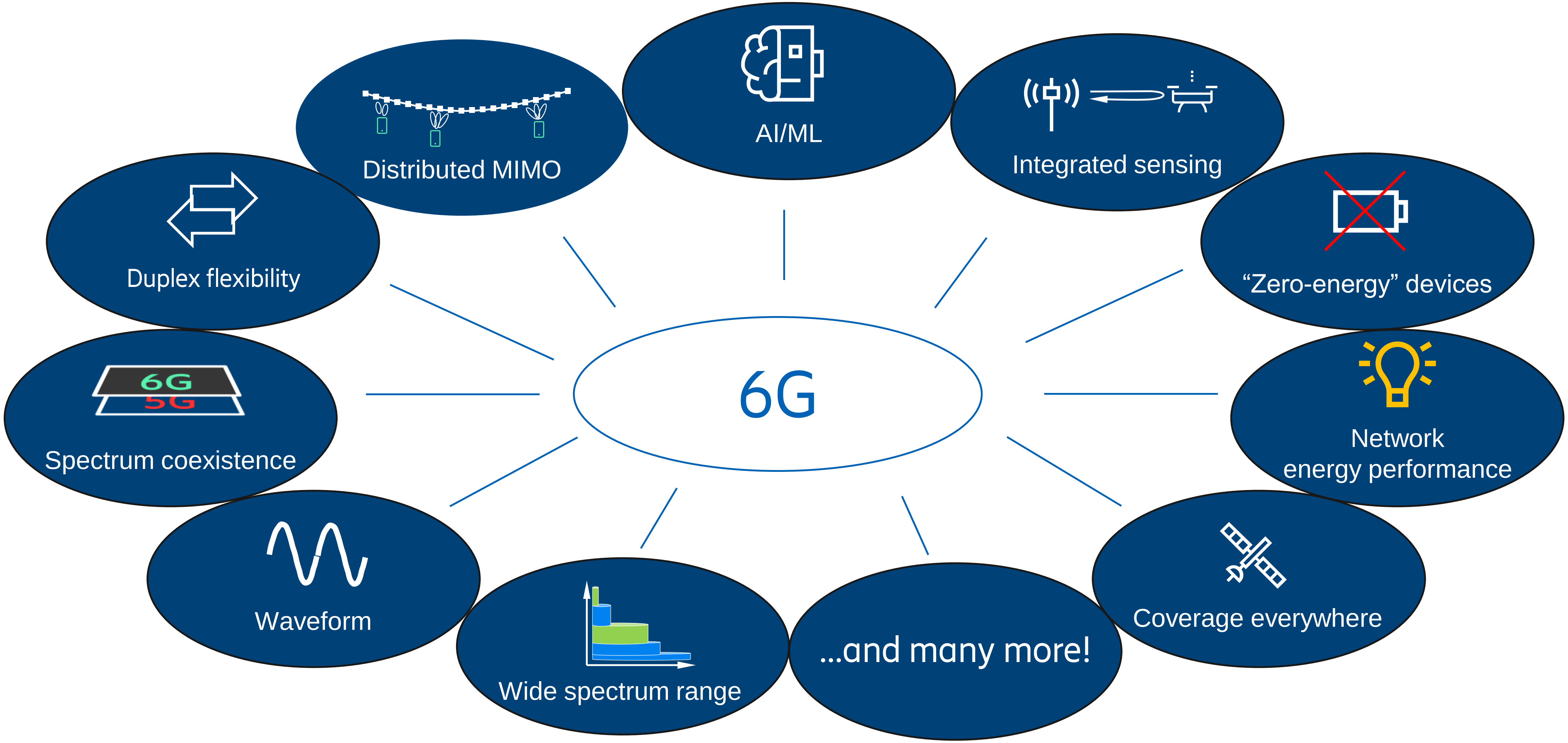

Now
2022
2023
2024
2025
2026
2027
2028
2029
2030
Rel-18
Rel-19
Rel-20
Rel-21
Rel-22
5G Evolution
6G req's
6G study item
6G work item
6G evolution
6G Commercial Launch
Requirements & evaluation criteria
Workshop
"IMT-2030" proposals
"IMT-2030" spec.
WRC-23
WRC-27

Key 6G principles

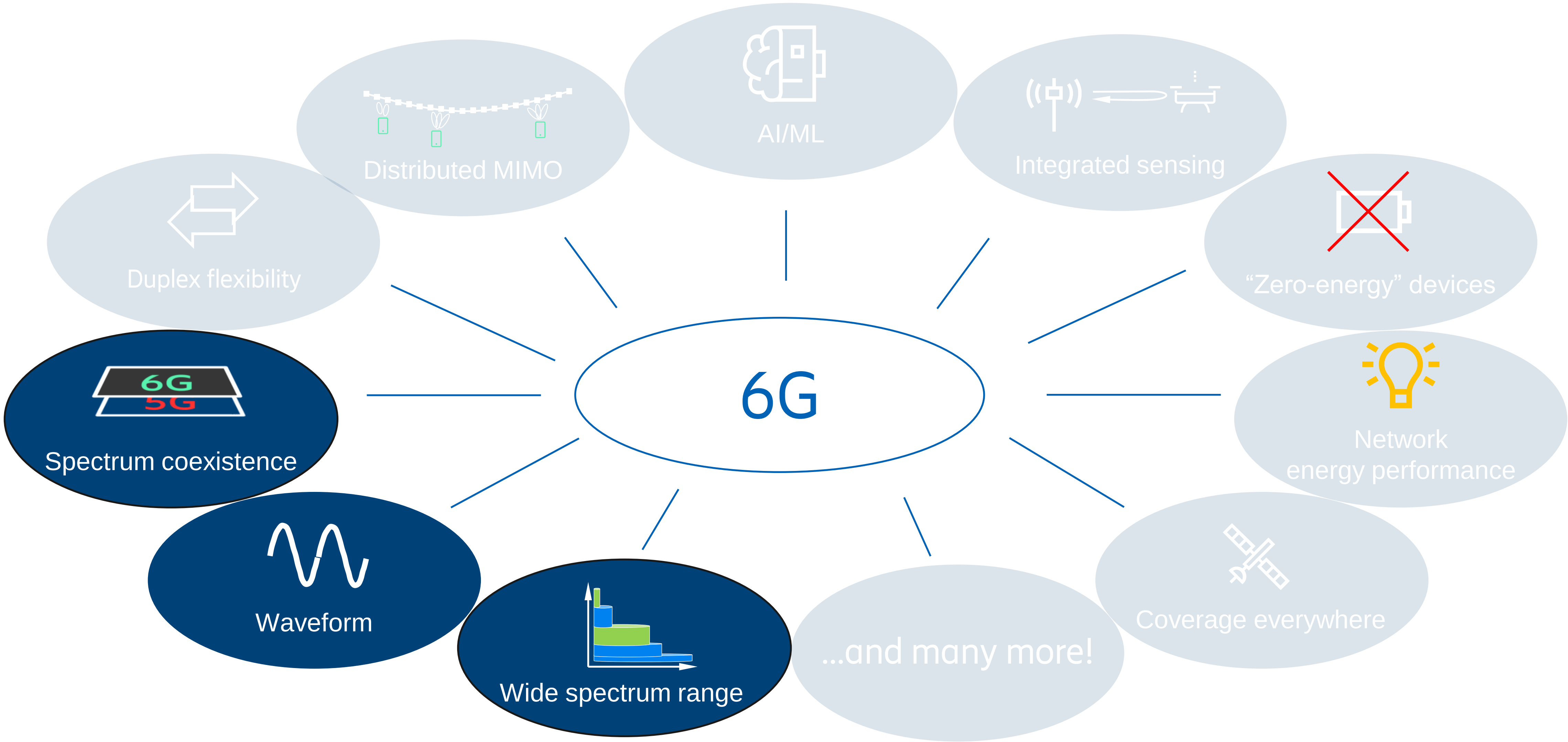
- Strive for a **global 6G standard**
- Single, simple, and **smooth migration path** from 5G to 6G
- 6G RAN shall have a **standalone** architecture
- Include **open interfaces** to facilitate a healthy ecosystem
- 6G shall be possible to **operate in all existing and new 3GPP bands**
- **6G spectrum sharing** shall be supported with selected 3GPP technologies



6G technology components



6G technology components



6G spectrum

From below 500 MHz to beyond 100 GHz

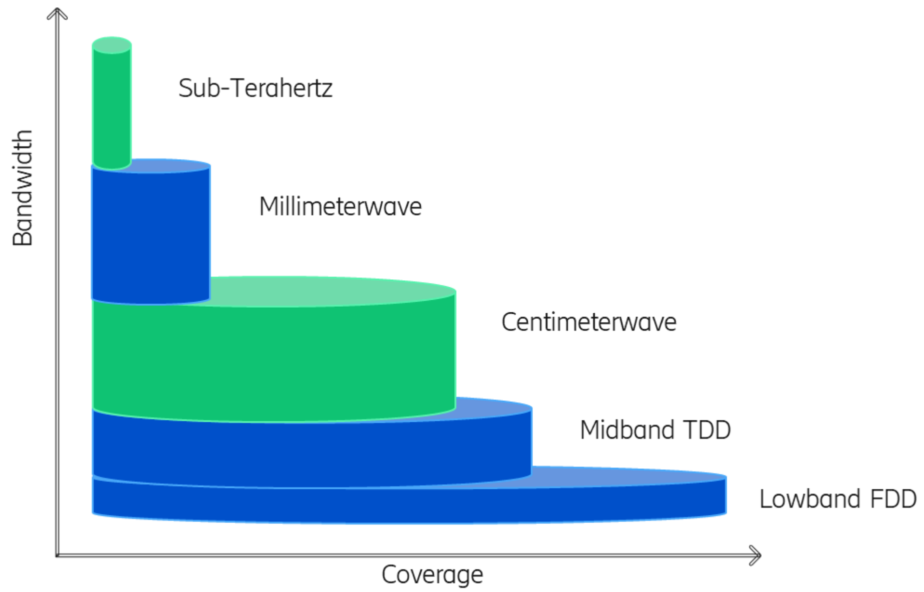
Spectrum used by current systems (“sub-6” and “mmw”)
➡ dynamic spectrum sharing

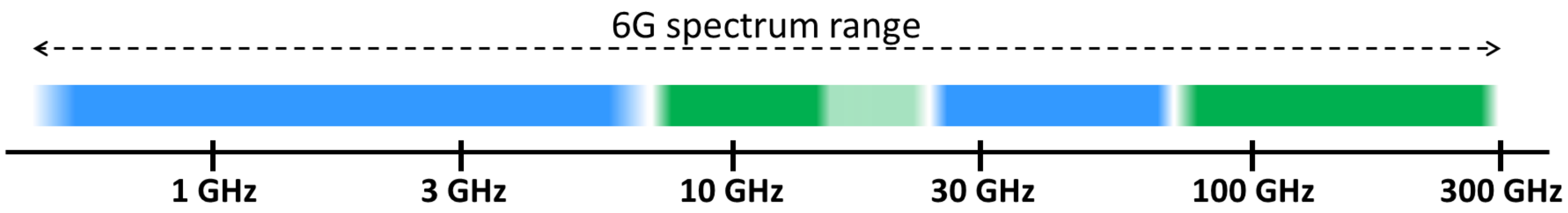
New spectrum between “sub-6” and mmw bands

- “Centimeter-wave”
- Focus on 7-15 GHz

New spectrum above 71 GHz (“sub-THz”)

- For extreme data rates in specific scenarios





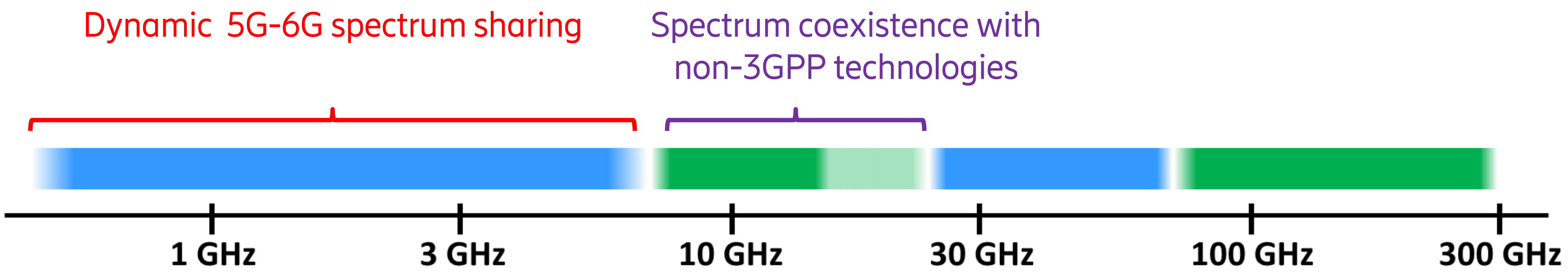
Spectrum sharing

Dynamic spectrum sharing with earlier 3GPP technologies essential for FR1

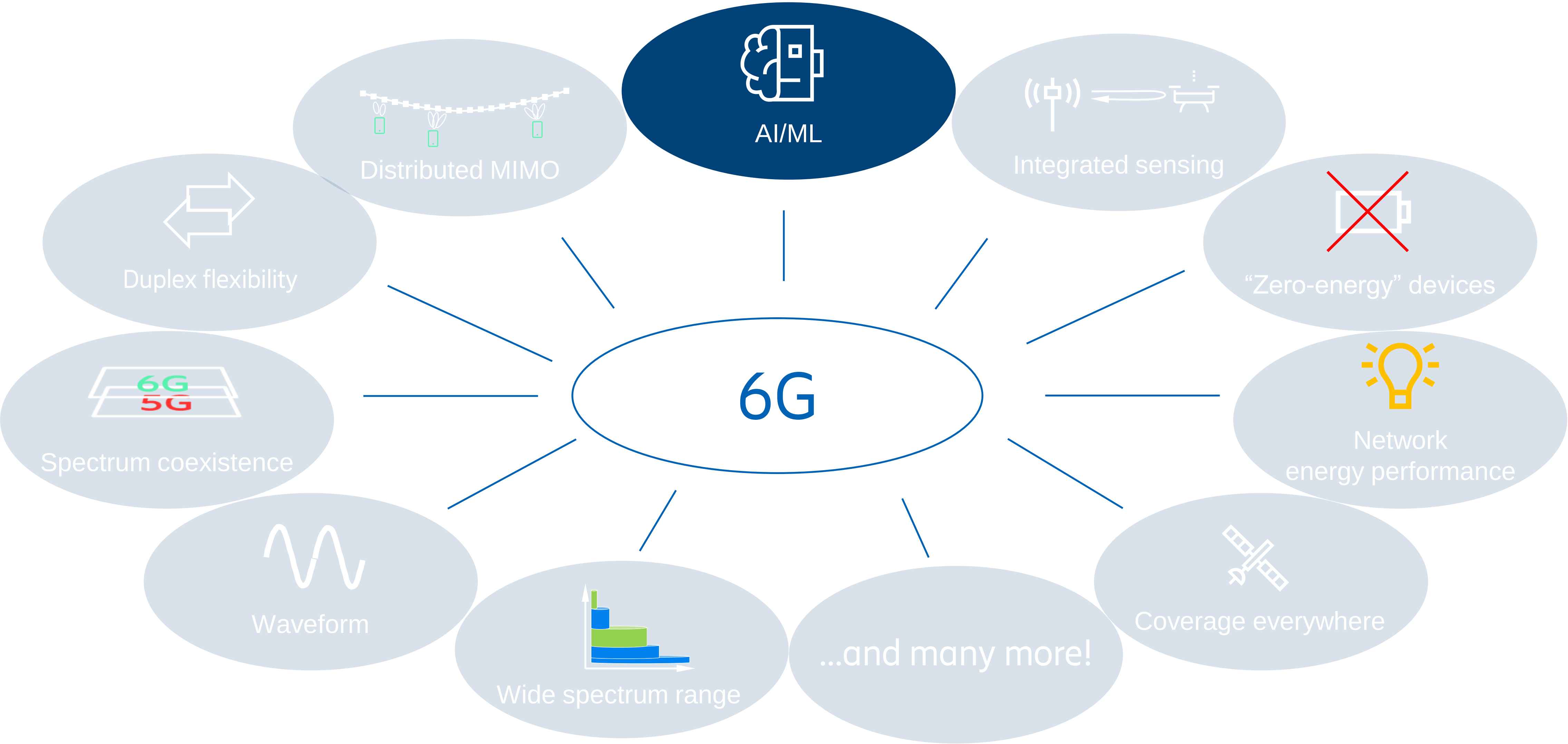
- “No” new spectrum in FR1 expected
- Highly efficient 5G – 6G sharing required
- Basic sharing with catM/NB-IoT

Spectrum coexistence with non-3GPP technologies for centimeter waves

- To access new spectrum currently used for other purposes (satellites, radars, fixed links, …)



6G technology components



AI and Machine Learning

AI and Machine Learning will play an important role in 6G

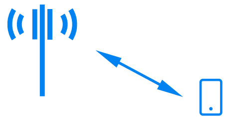
- Hard-to-model problems, non-linear effects, …

Need to account for complexity and energy consumption

3GPP Rel-18/19 work on AI/ML likely to form the basis for 6G

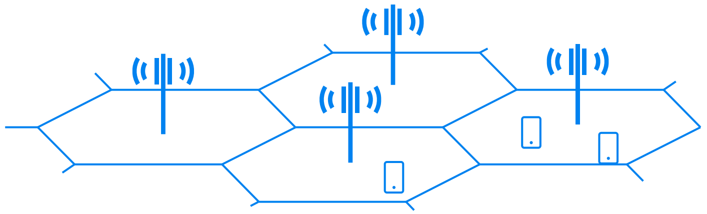
- Standardizing distributed AI learning/models is challenging

AI within the air interface



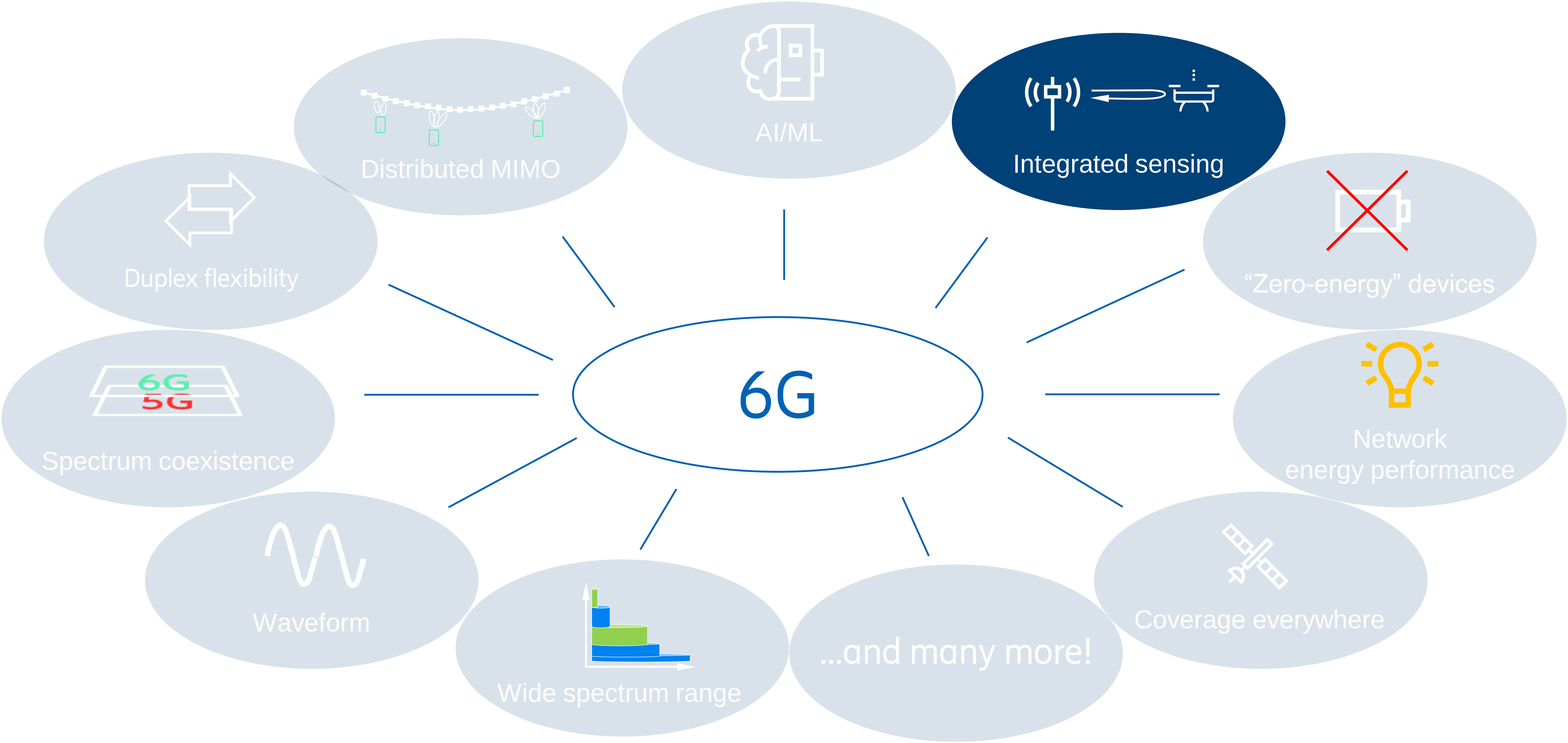
Channel estimation/prediction, beam management, hardware impairments, …

AI within the RAN



Radio-resource management, deployment, management and orchestration, …

6G technology components



Joint communication and sensing (JCAS)

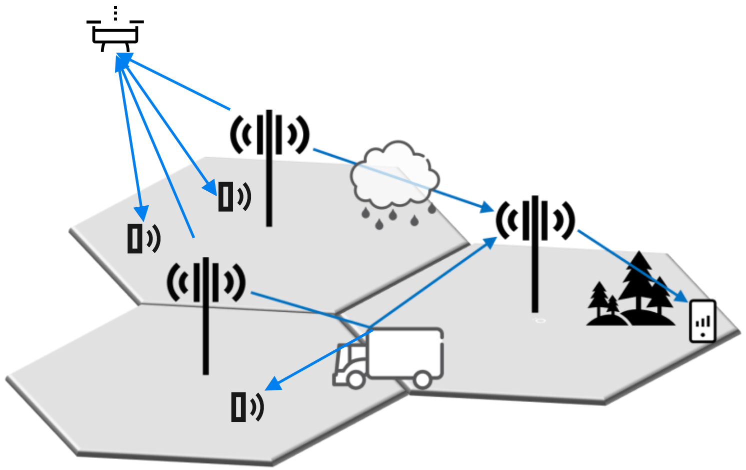
Sensing functionality as an *integrated* part of the communication network

- Reuse the communication spectrum for sensing
- Reuse the communication infra-structure for sensing

⇩

Low-cost introduction of sensing functionality

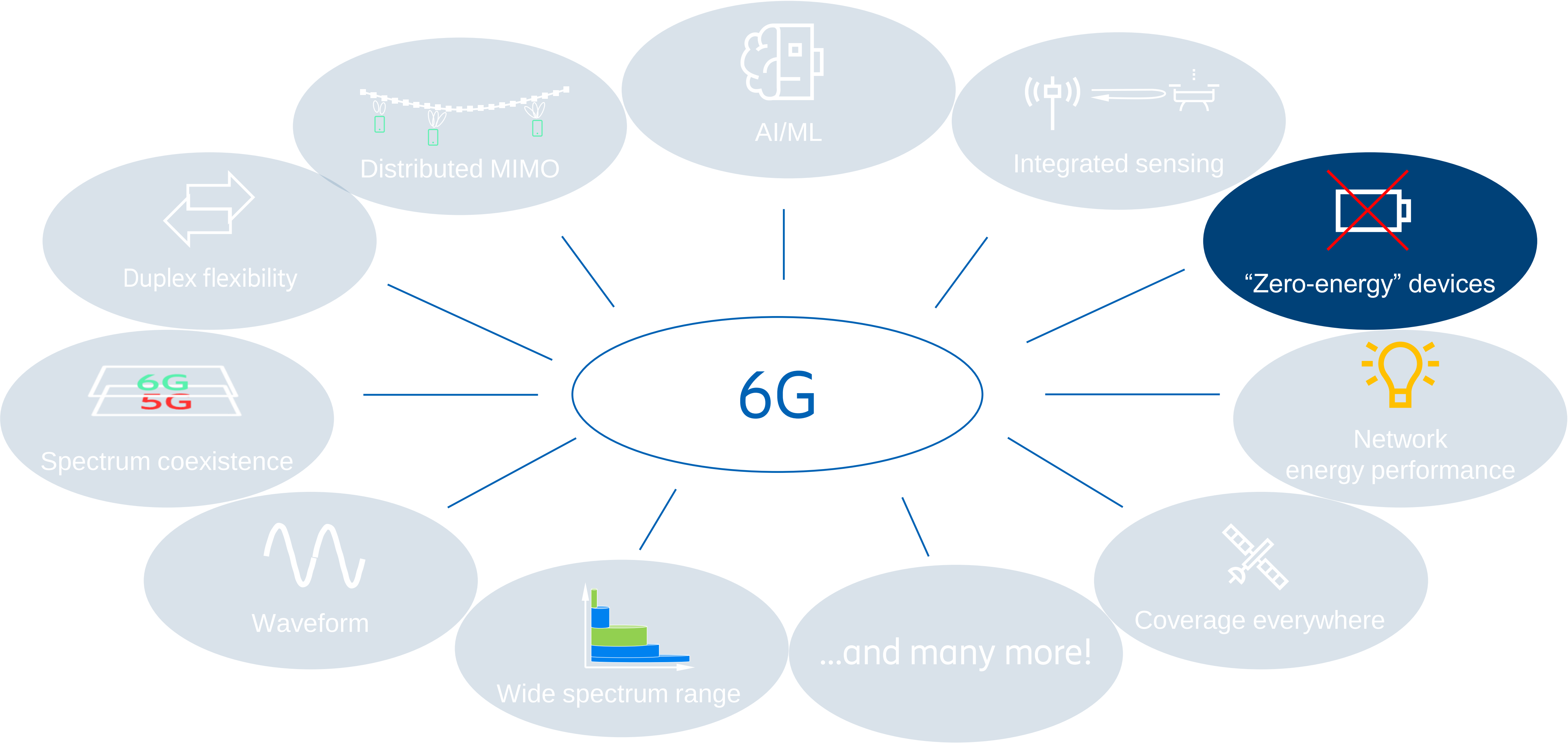
Benefit from huge number of co-operative network nodes



Multiple uses

- Enable new/enhanced end-user services
- Enhance the network performance,
  including detection of electromagnetic threats

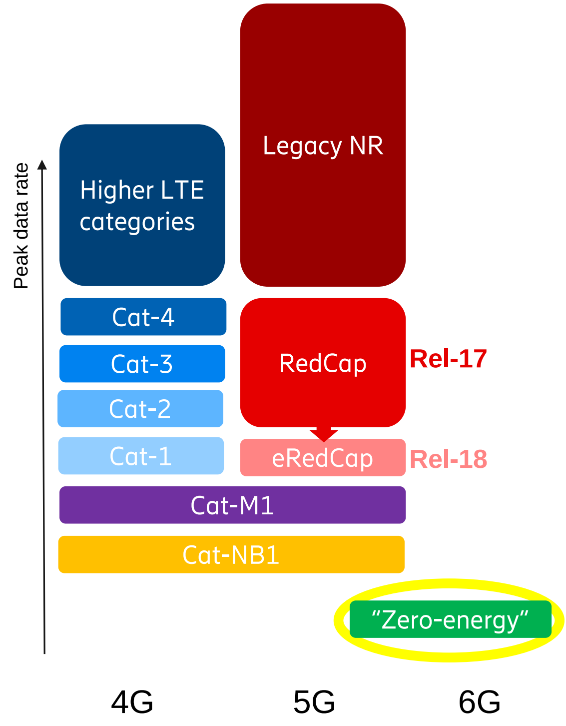
6G technology components



"Zero-energy" devices

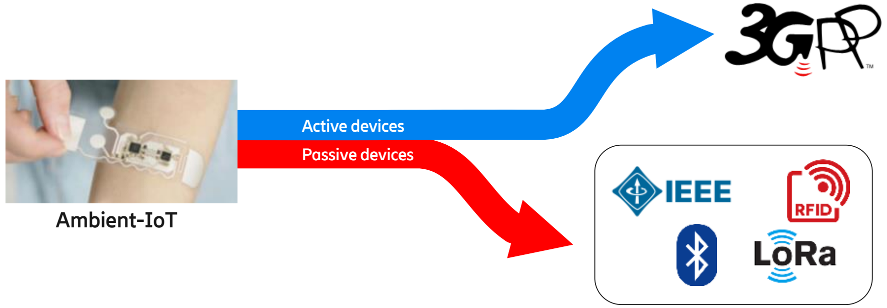
Devices harvesting ambient energy (solar, temperature, vibrations, RF, …)

- *"No need to change battery"*
- Enabling sustainable asset trackers, sensors for mass deployment, …



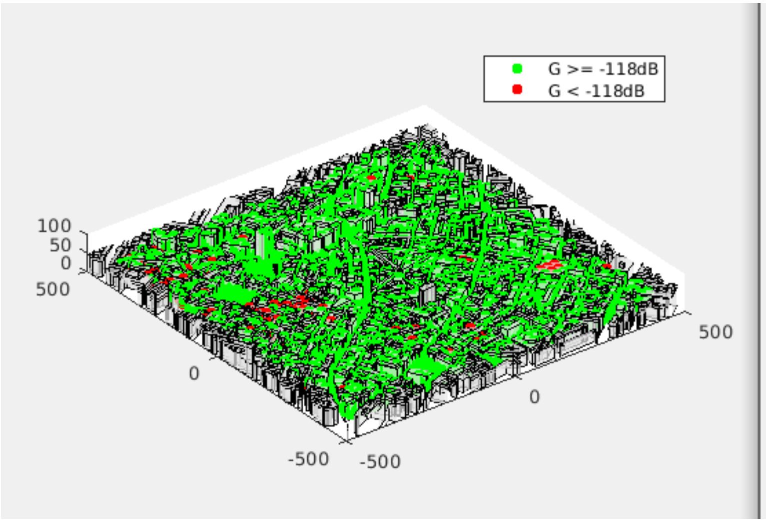
Rel-19 ambient IoT has a partially similar scope

- Focus on active Tx/Rx solutions, not backscattering (backscattering has a limited coverage of ~10 m)

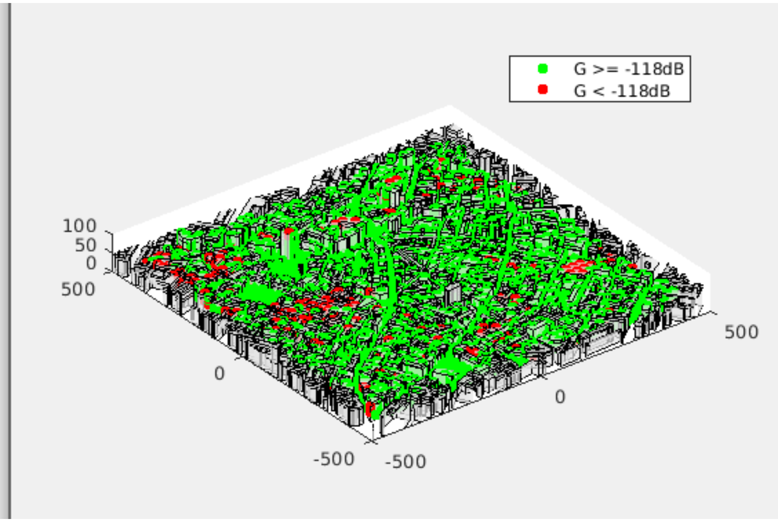


Where does it work? Initial estimates for London

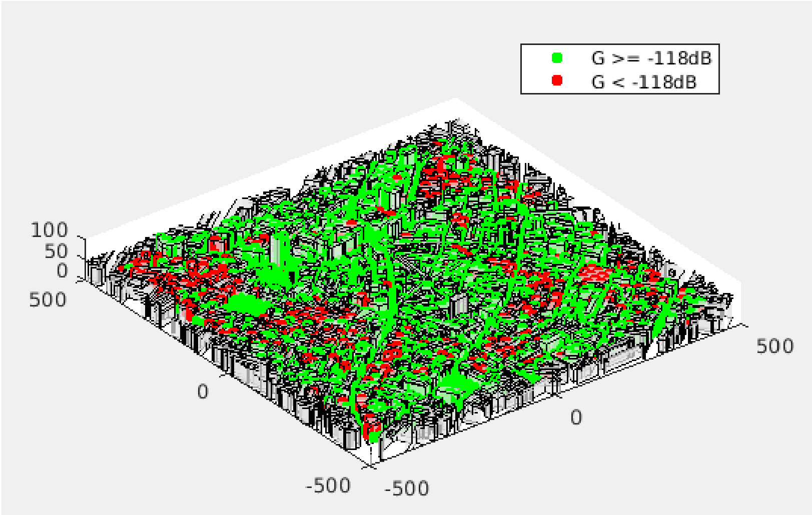
800MHz



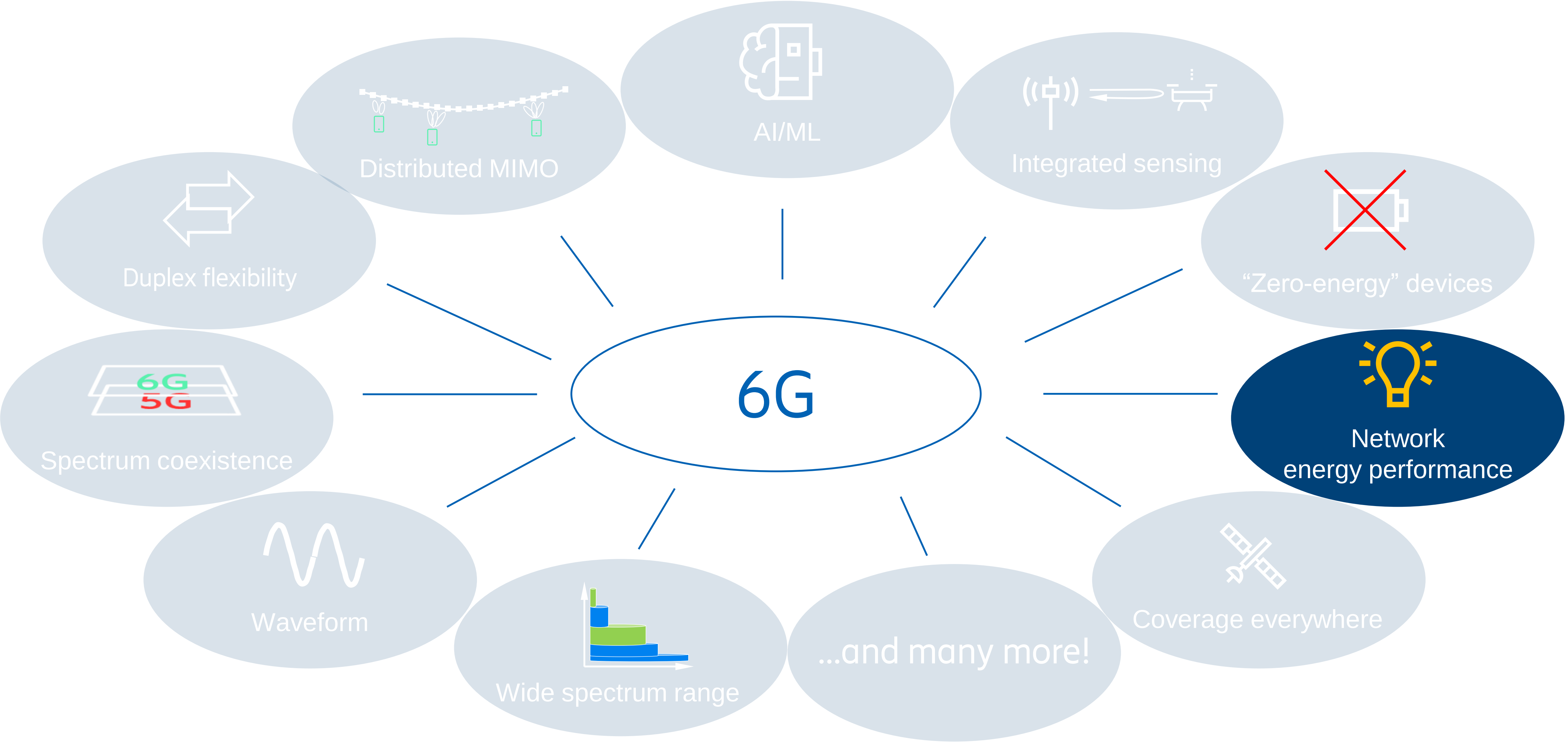
1800MHz



3.5GHz (No BF)

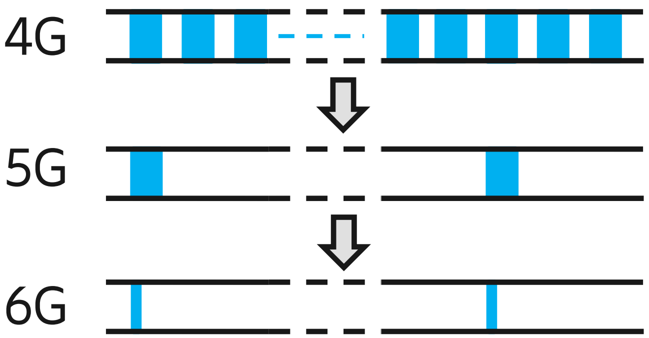


6G technology components

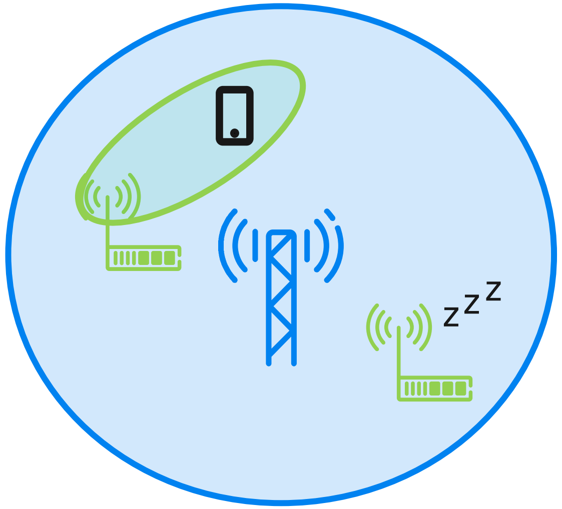


Energy efficiency – Lean design remains key!

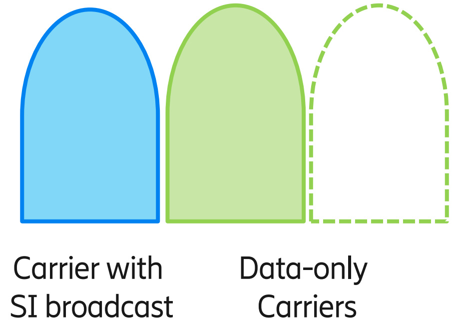
Enhance lean design in time domain



Extend lean design to spatial/node domain



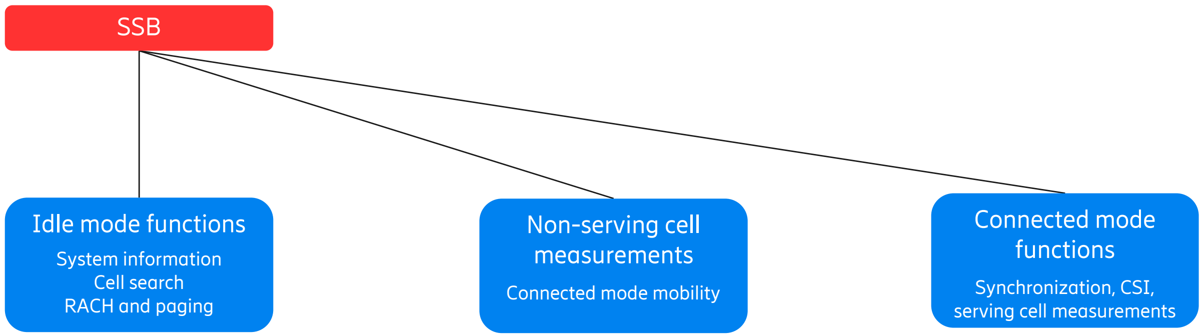
Extend lean design to frequency domain



Decoupling idle and active states

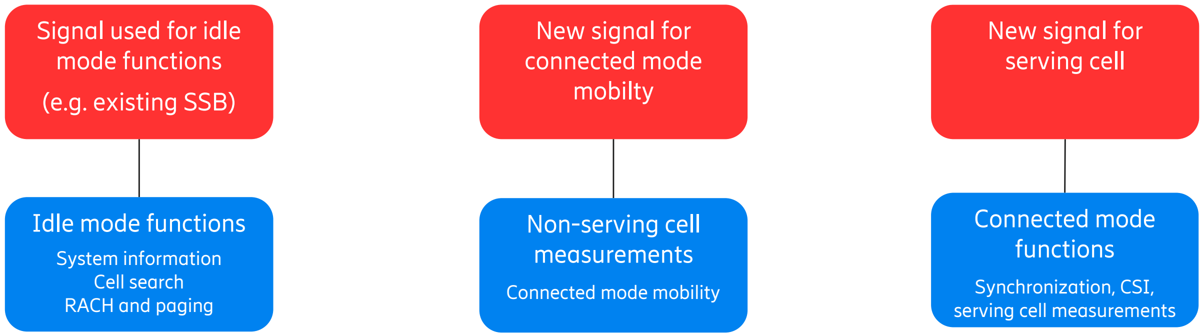
5G

- SSB used for both idle and connected mode procedures
- The spec allows mobility measurements on CSI-RS but it is not used in the field

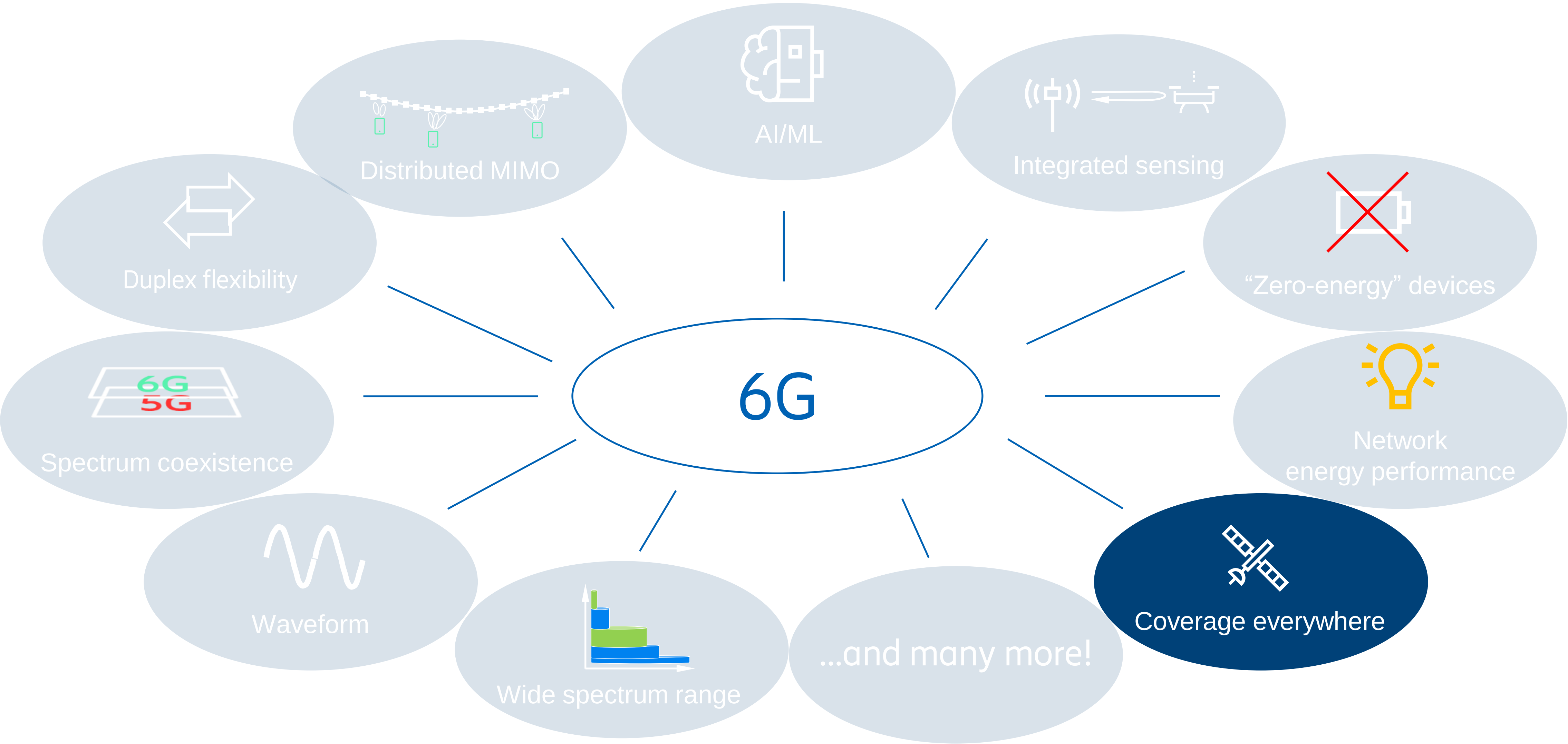


6G

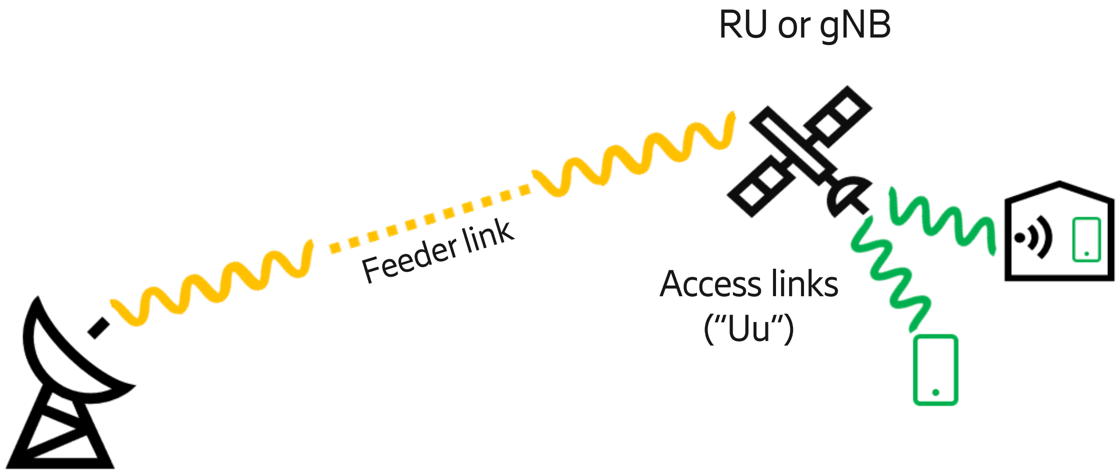
- Separate signals for idle and connected mode procedures
- Enables separate optimization for different states



6G technology components



Non-terrestrial access

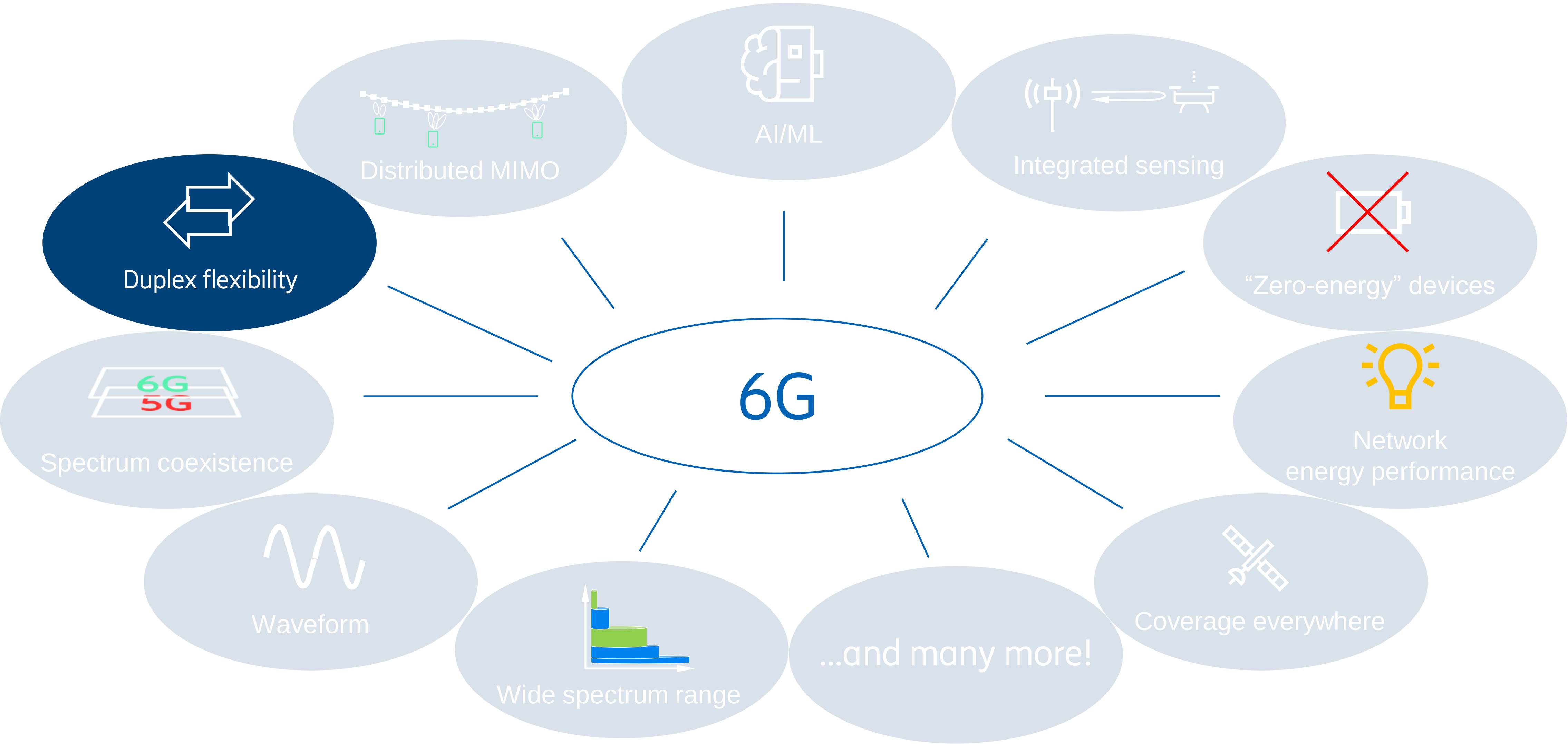


NTN as a *complement* to terrestrial access to provide coverage

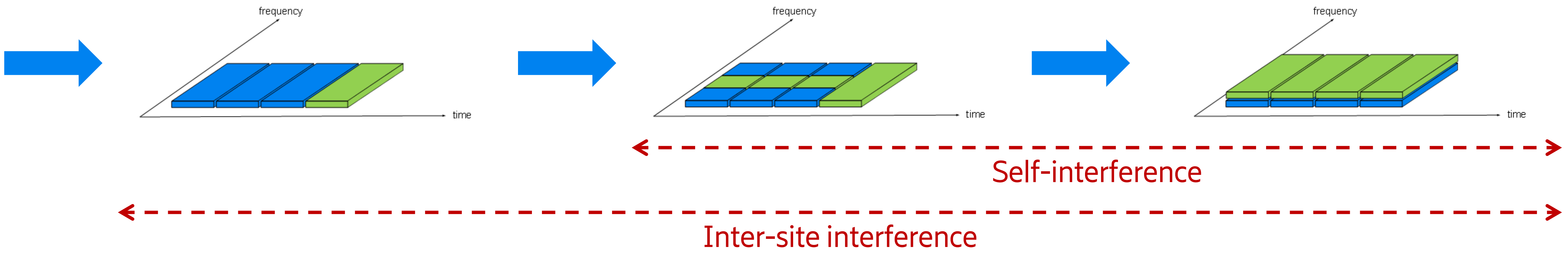
Reuse terrestrial access-link technology for the satellite access link

Allow for either RU or complete gNB to be located in the satellite

6G technology components



Duplex evolution/flexibility



Dynamic TDD

- Inter-site interference needs to be handled before considering the self interference

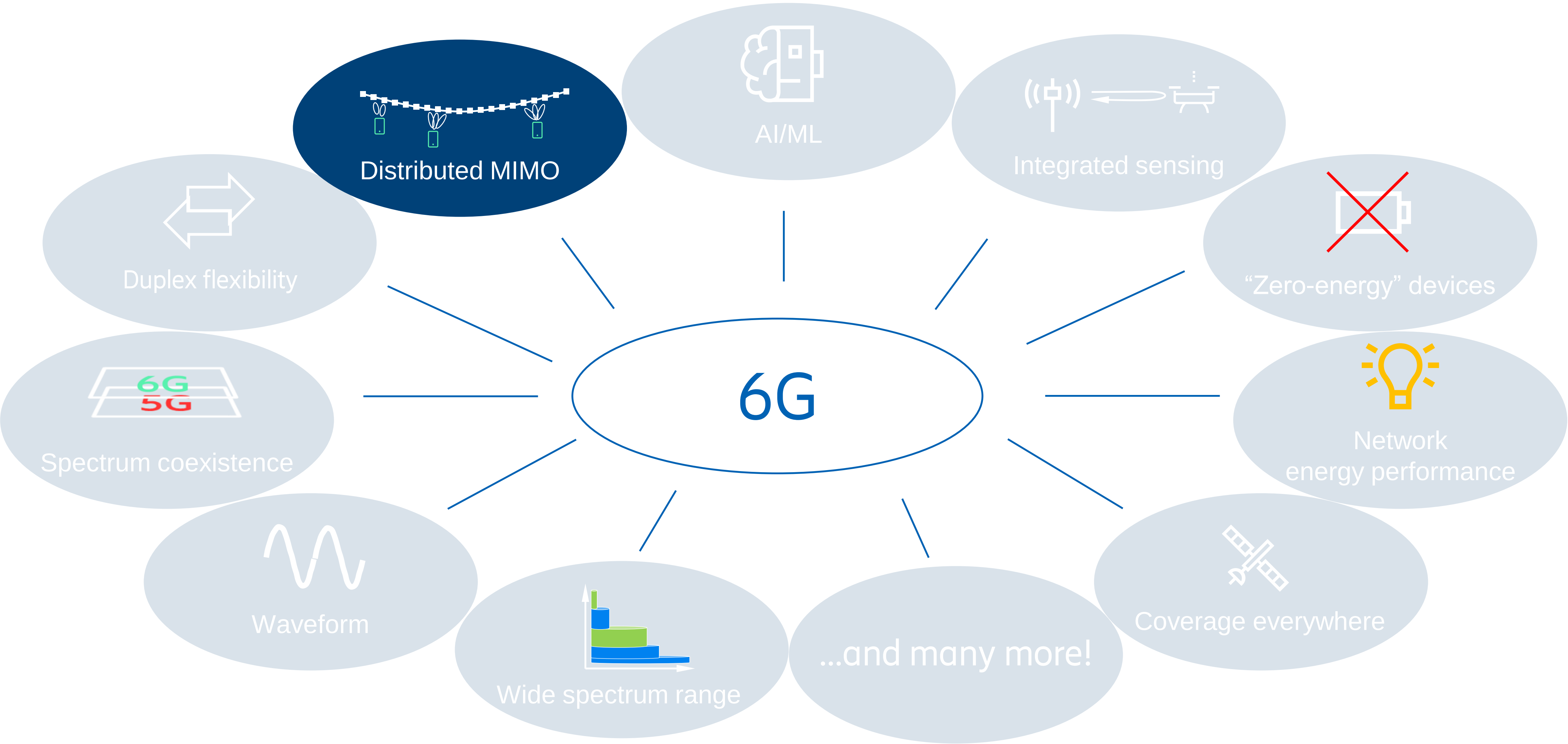
Subband full duplex:

- Possible for low-power nodes

Same-frequency full duplex

- Difficult implementation, limited capacity gain

6G technology components



MIMO in 6G

6G MIMO will build on the 5G MIMO framework

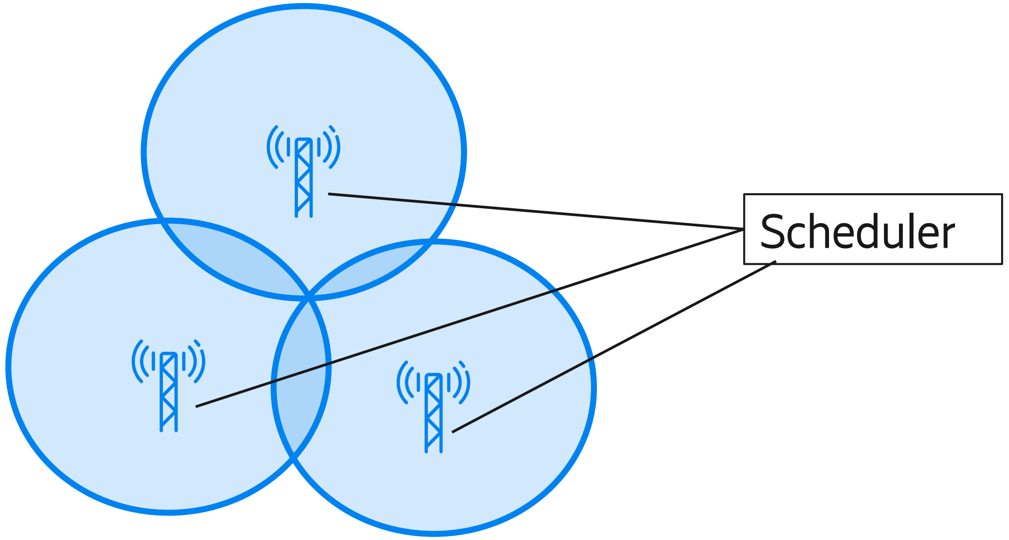
- Massive MIMO will remain important – reuse of current site grid
- Distributed MIMO will increase in importance – useful for dense deployments

"Scalable" design

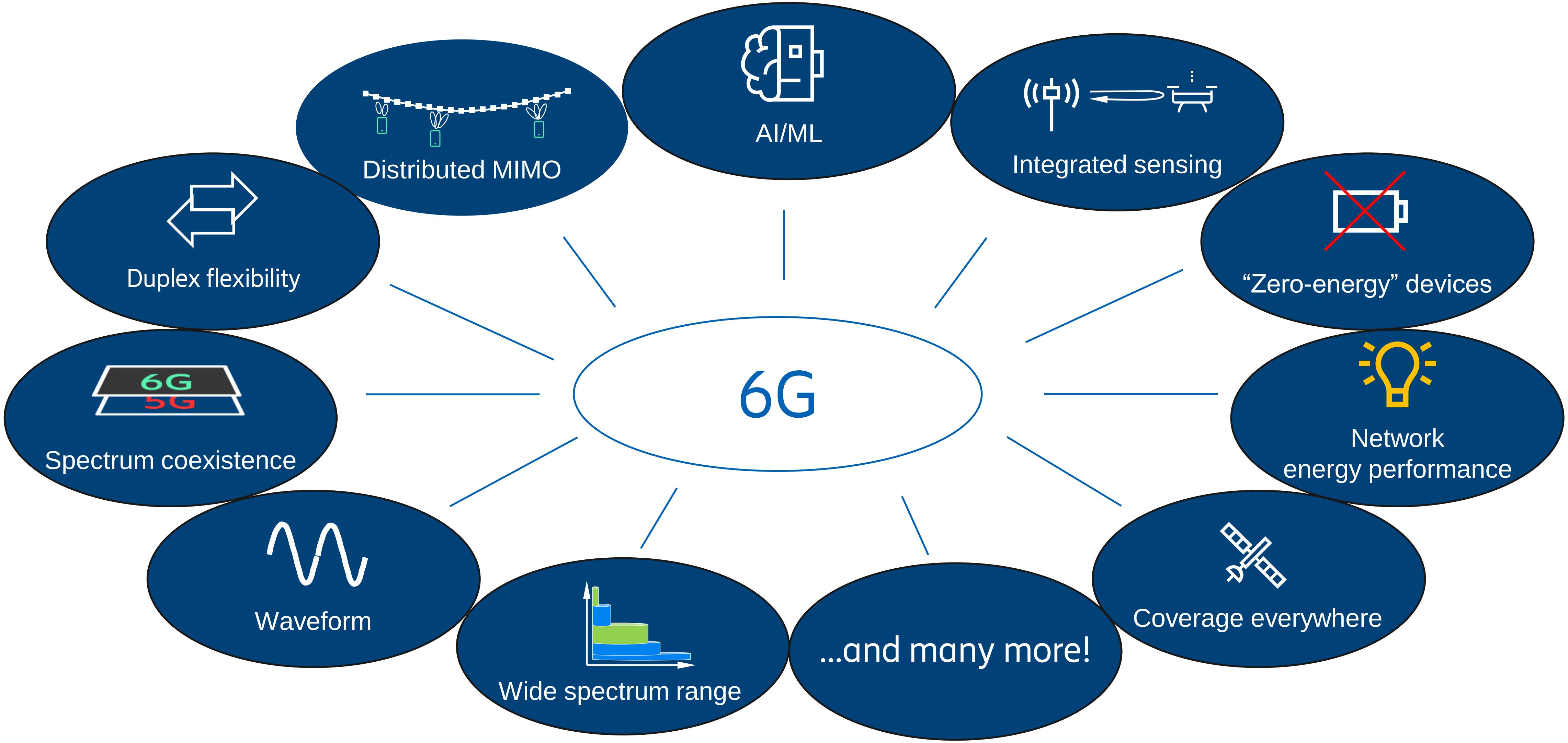
- Dynamically adapt number of RF chains
  to reduce energy consumption

Trend towards scheduling across multiple TRPs and carriers

- Largely an implementation aspect but refined signaling
  structures can simplify coordination
- Improved spectral efficiency, improved energy efficiency,
  cloud-friendly implementation



6G technology components

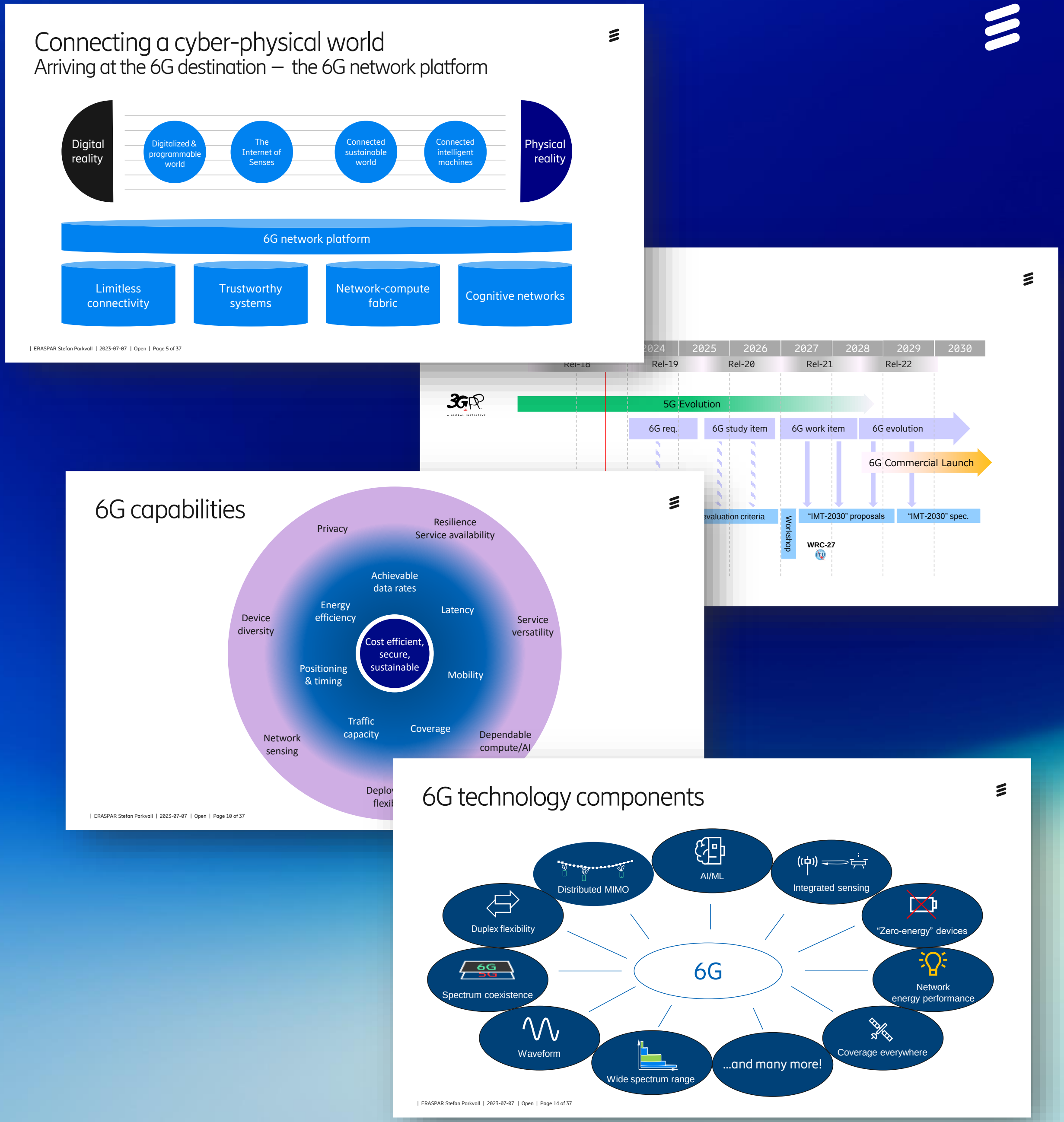


Summary

"6G" is the overall platform solution around 2030

New capabilities for new use cases

Wide range of technologies considered




Countless numbers of sensors in the physical world
nature electronics