6G series workshop by Hexa-X-II

Characteristics and classification of 6G device classes

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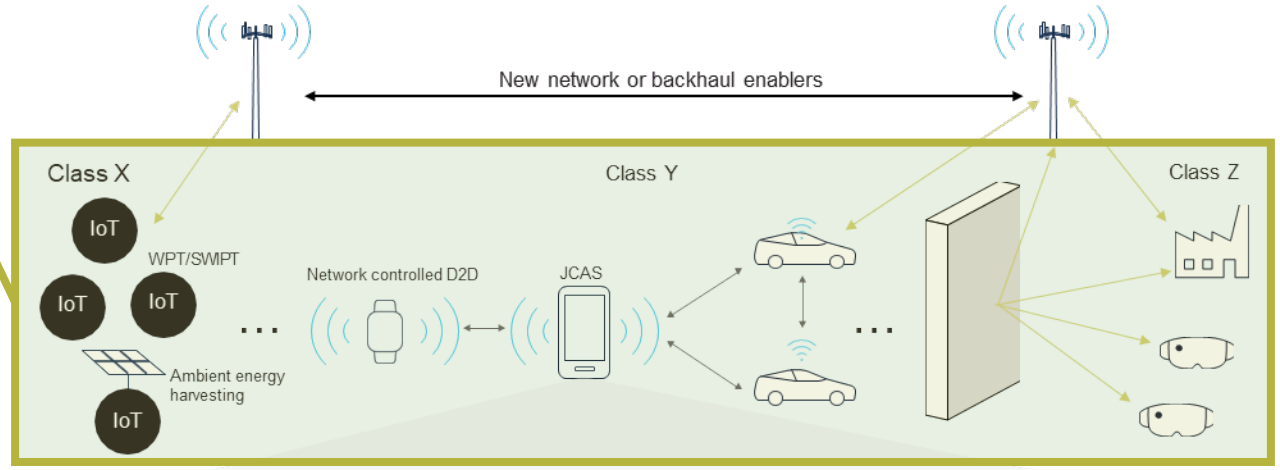
Hexa-X-II

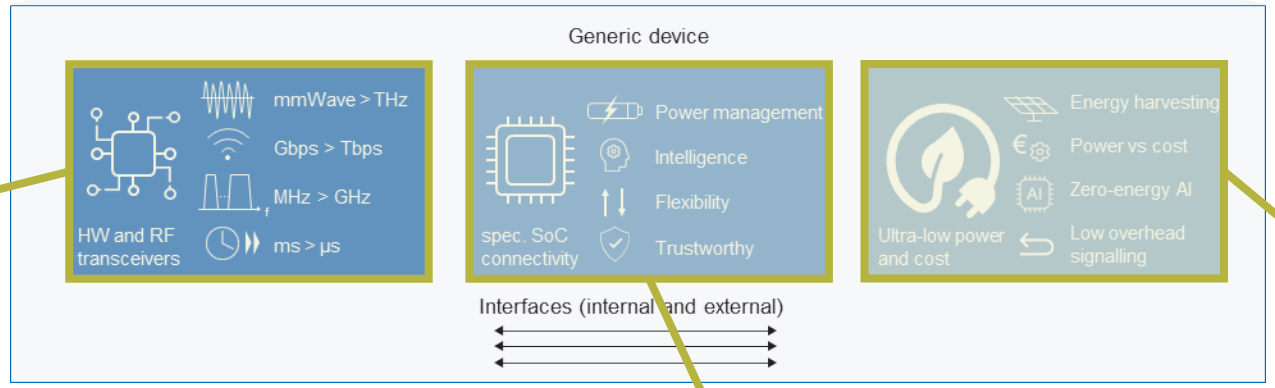
hexa-x-ii.eu

Hexa-X-II - WP5
Future devices and flexible infrastructure

T5.1: Classification of novel **6G device classes** and infrastructure enablers

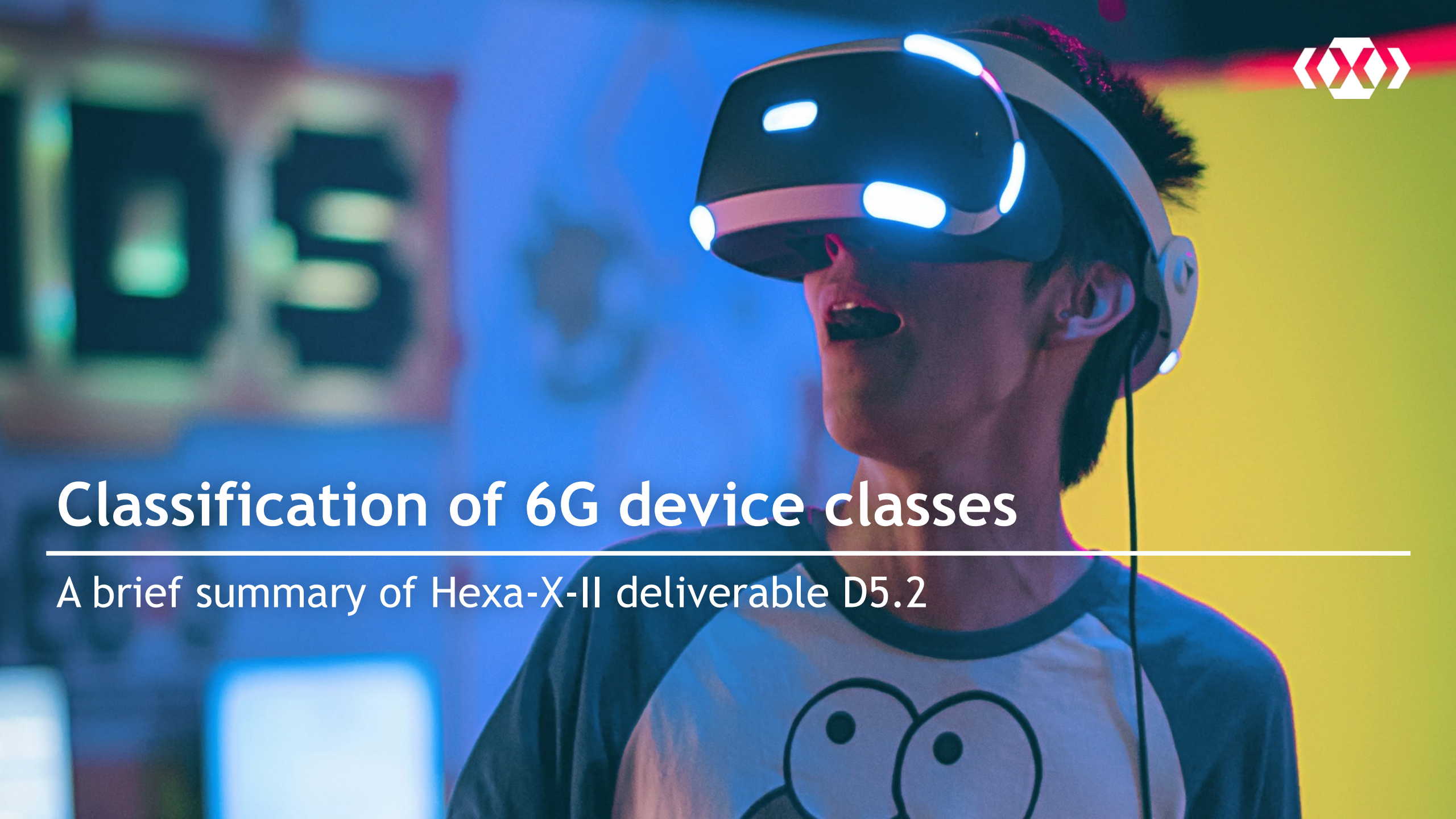


T5.2: HW and **RF transceivers** for 6G



T5.4: **Ultra-low power/cost** device and communication designs

T5.3: General purpose vs. specialized **SoC connectivity**



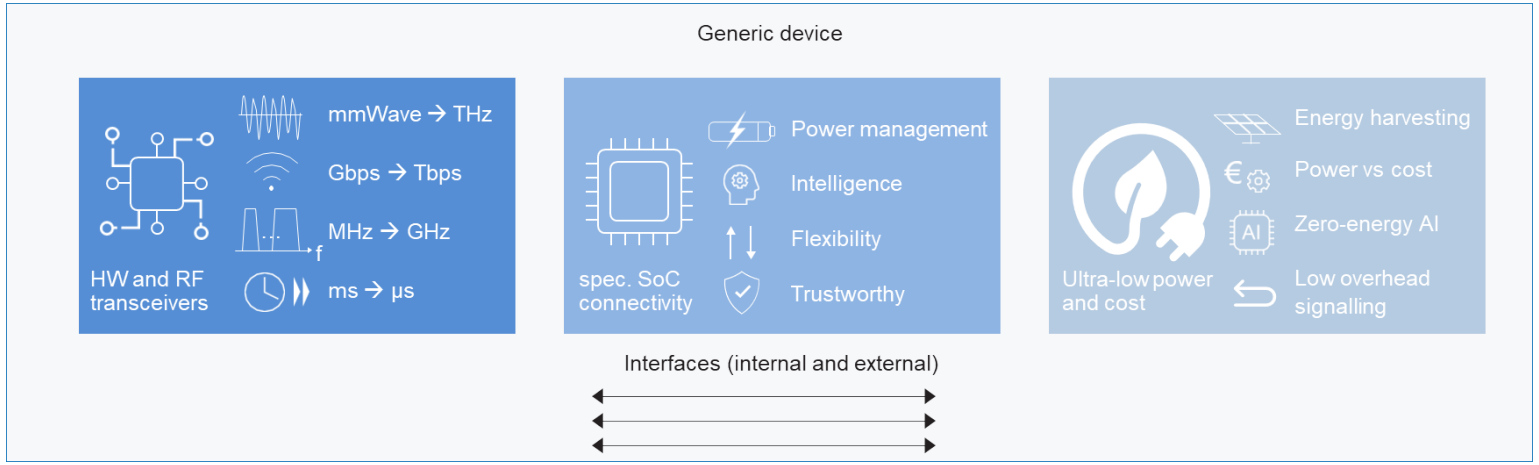
Classification of 6G device classes

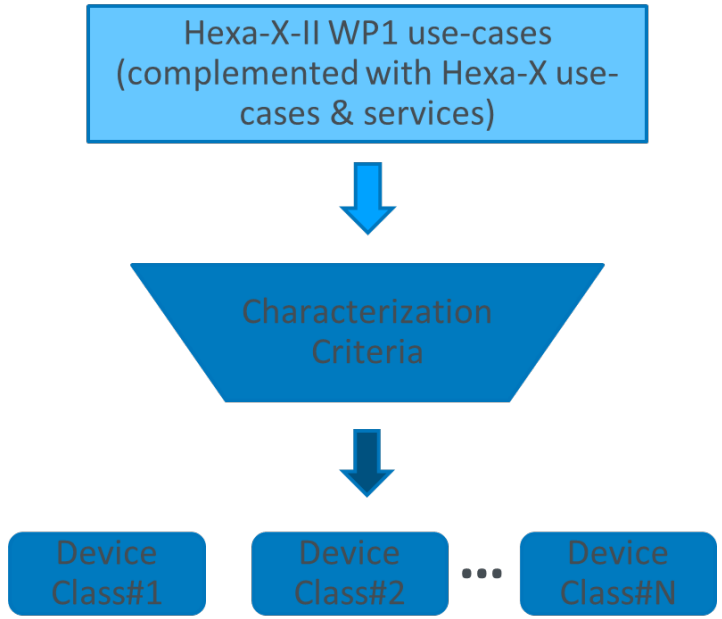
A brief summary of Hexa-X-II deliverable D5.2

Key Definition

What is a device in Hexa-X-II?

- Hexa-X-II defines a device specifically as an end-device that is connected to the network infrastructure via a radio interface, uniquely identifiable, and which generates and/or consumes application data
- The considered device consists of RF transceiver circuitry, a System-on-Chip (including a CPU, memory, and peripherals), and the necessary firmware and software.





Use-cases and devices realizing them

- Cobot (IoT/M2M)
- Mix of URLLC and eMBB services device

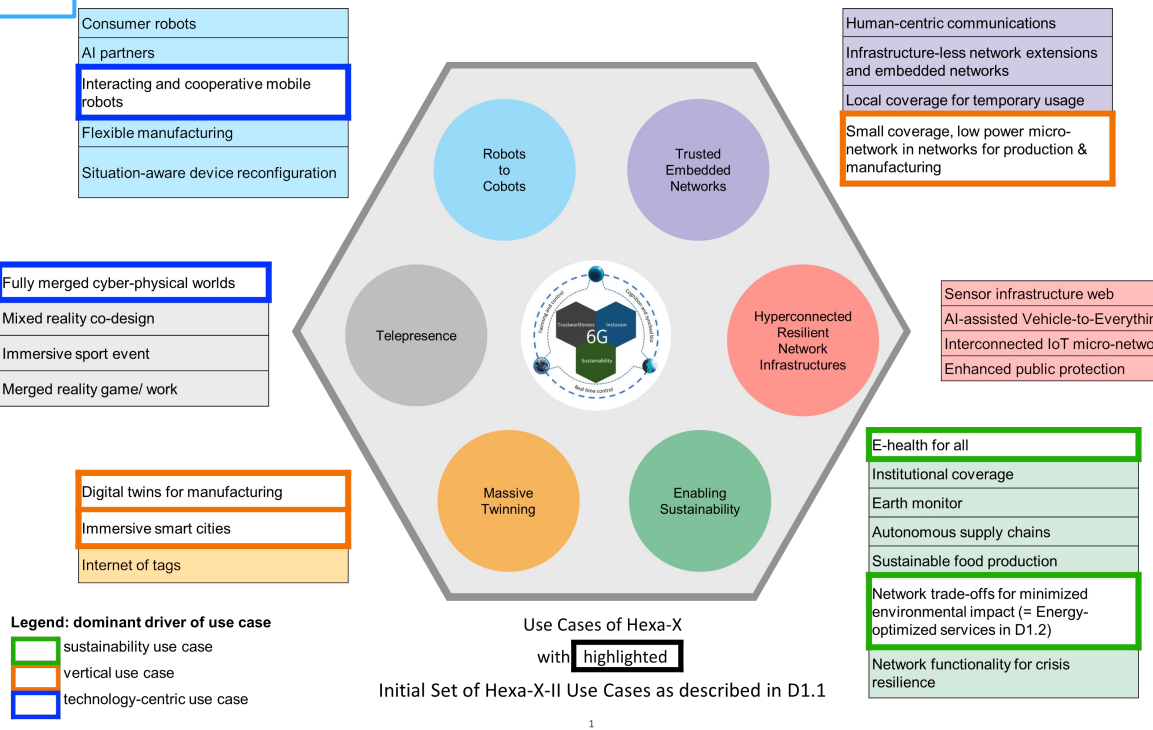
- Resilient/available IoT devices
- Trustworthy/intelligent aggregator devices

- (Reliable & available) XR devices
- On-body sensors and actuators + connectivity hubs….

- IoT devices

- Zero energy devices
- (bio-friendly) Tags, zero e-Waste IoT

- Implantable devices
- Zero energy devices
- (bio-friendly) Tags, zero e-Waste IoT



Main takeaways:

- One device might serve multiple use-cases and have suitable implementation/design adaptations for specific use-case
- Multiple devices are often needed to realize a single use-case

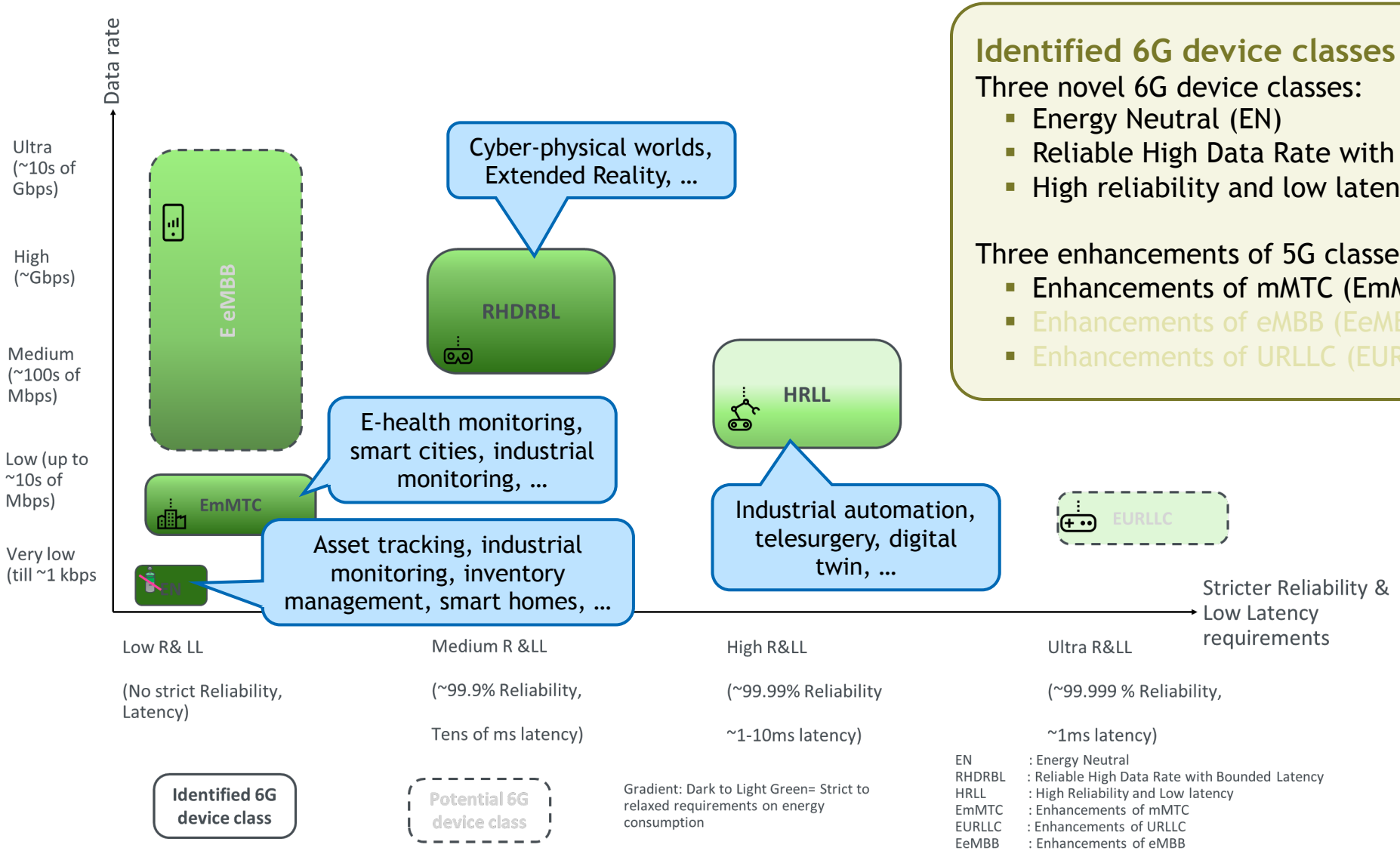
Characterization criteria

- Set the basis to understand if **different 6G devices** fall into a one device class or another.
- There are **numerous characteristics** concerning a device, such as its energy consumption, operating spectrum, authentication, etc.
- The **granularity is set at a coarse level** to serve as a guide and depending on the exact implementation etc.

Group	Characteristic
Energy	Energy source
	Energy storage
	Energy consumption during (1) operation (2) idle/sleep
Lifetime	Device lifetime
Mobility	Device mobility
Communication	Authentication
	Synchronization
	Time aware system component
	Spectrum
	Traffic flow
	Data rate
	Latency
	Reliability
	Availability
	NTN support

Group	Characteristic
AI & computation	Computation capability
Localization & sensing	Location accuracy
	Orientation accuracy
	Localization/sensing latency
Security	Security capability

Identified 6G device classes



Identified 6G device classes

Three novel 6G device classes:

- Energy Neutral (EN)
- Reliable High Data Rate with Bounded Latency (RHDRBL)
- High reliability and low latency (HRLL)

Three enhancements of 5G classes (eMBB, URLLC, mMTC):

- Enhancements of mMTC (EmMTC)
- Enhancements of eMBB (EeMBB)
- Enhancements of URLLC (EURLLC)

6G device and infrastructure enablers

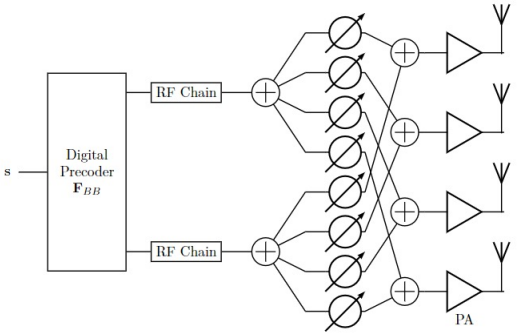
A peek into Hexa-X-II deliverable D5.3

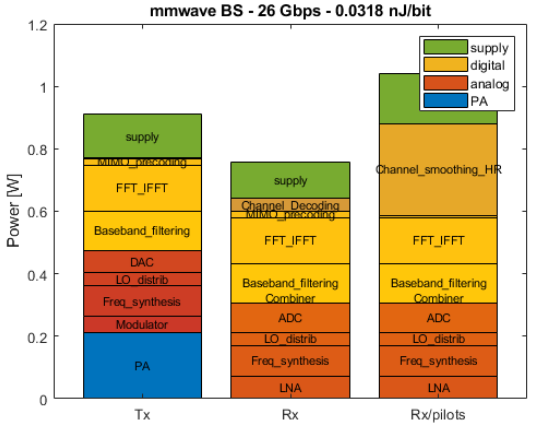
Hexa-X-II – WP5
6G device enablers

T5.1: Device types	T5.2: HW and RF transceivers for 6G	T5.3: Specialized SoC connectivity	T5.4: Ultra-low power devices and comms
Reliable High Data Rate with Bounded Latency (RHDRBL)	▪ Sub-THz transceivers ▪ Reflective Intelligent Surfaces	▪ AI/DSP accelerators ▪ Secure SoC architecture	
High Reliability & Low Latency (HRLL)	▪ Reflective Intelligent Surfaces	▪ AI/DSP accelerators ▪ Secure SoC architecture	
Enhancements of mMTC (EmMTC)		▪ Secure SoC architecture	▪ Energy-aware low-overhead protocols
Energy Neutral (EN)		▪ Multi-source energy harvesting ▪ Secure SoC architecture	▪ WPT/ backscatter ▪ Energy-aware low-overhead protocols

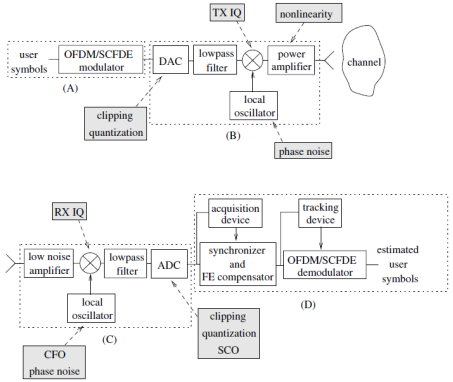
Sub-THz transceivers

1. Dimensioning of sub-THz architectures

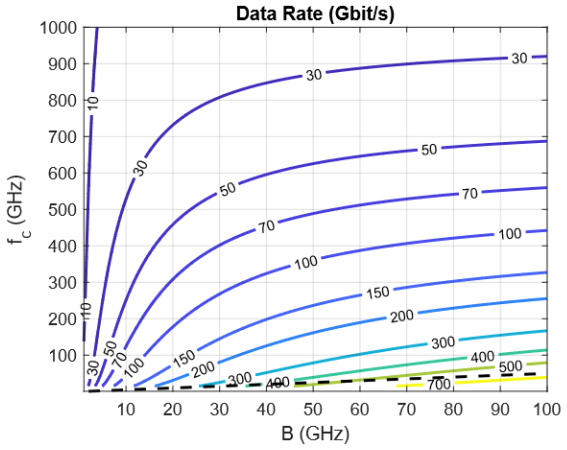


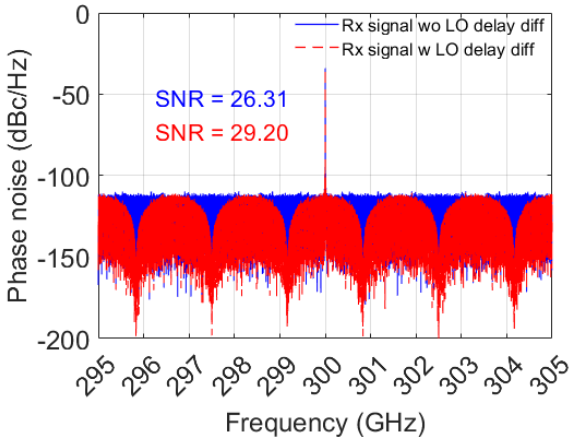


2. Models for main HW non-idealities

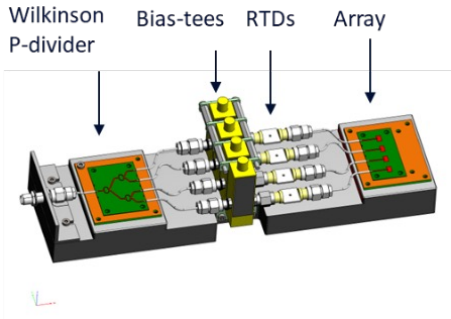


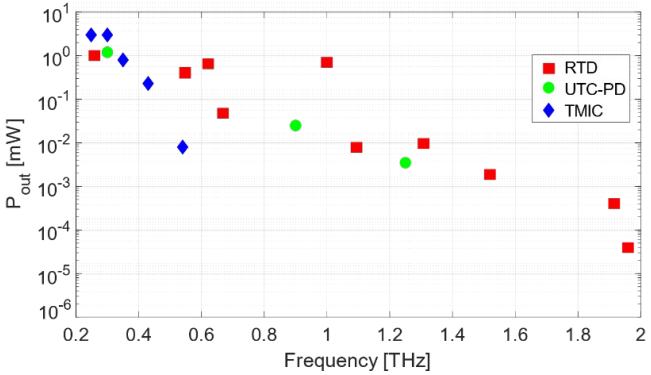
3. Phase-noise limited performance & asymmetrical LO



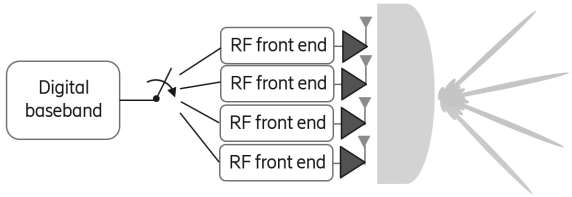


4. RTD-based architecture



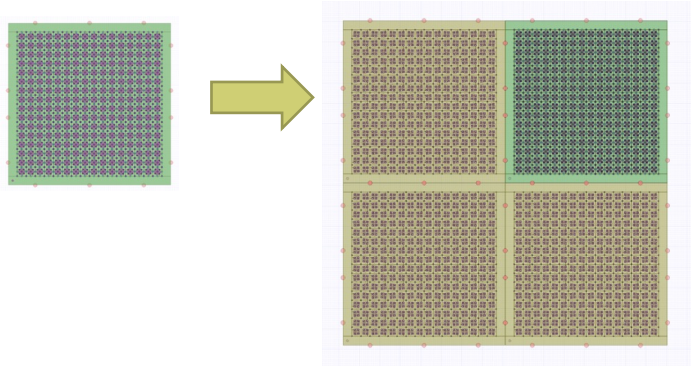


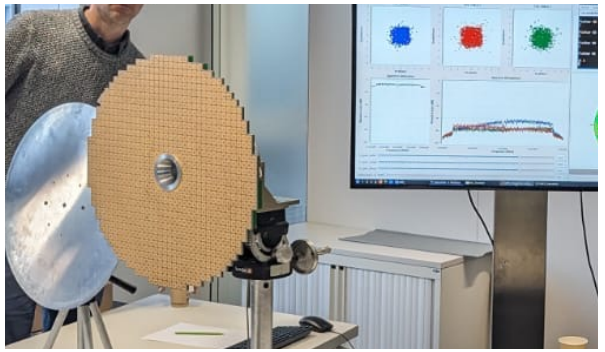
5. Switched-beam antenna lenses

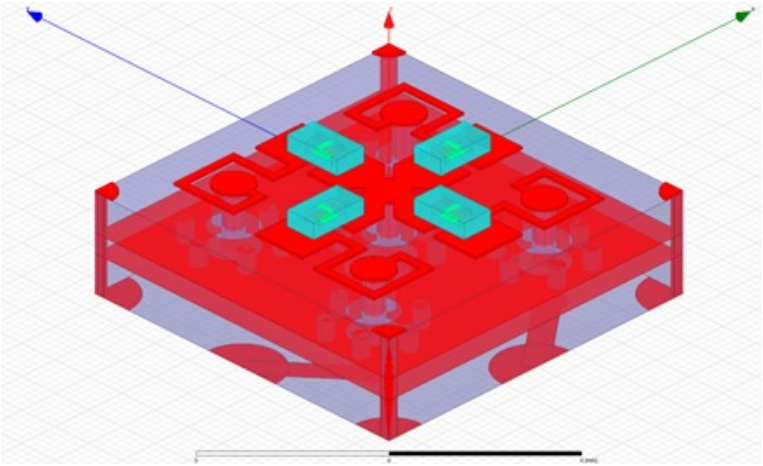


Reflective Intelligent Surface (RIS) design

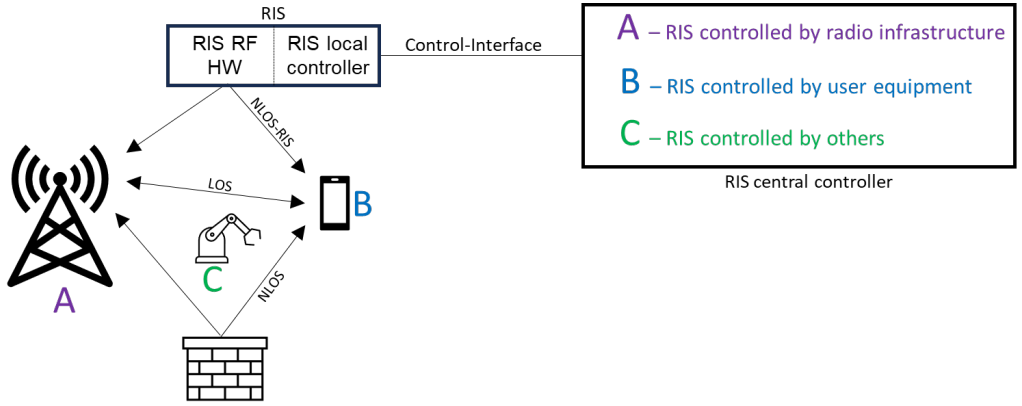
1. Reconfigurable RIS tiles
   - Dual polarization unit cell at mmWave RF2 frequencies
   - Continuous reflected phase control with at least 300°
   - 16x16 unit cells tile prototype





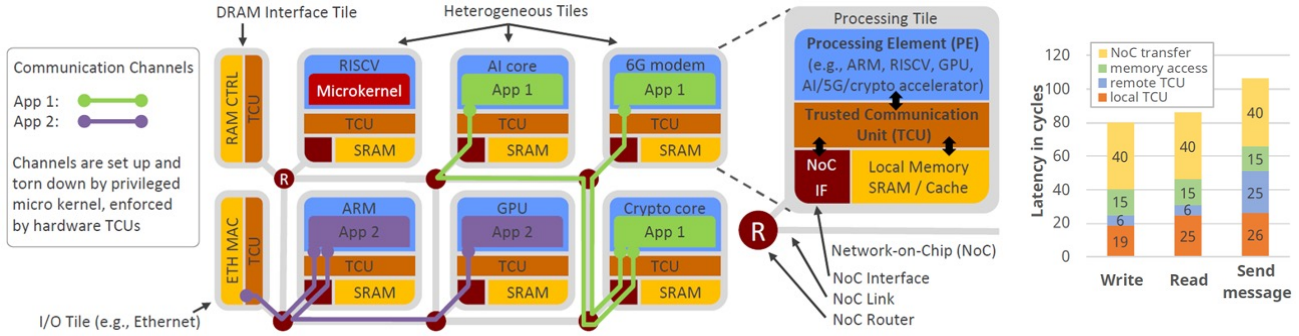


2. RIS system integration
   - Identifying key capabilities and limitations of RIS
   - Local control functionality
   - Control interface and protocol
   - Multiple control architectures (network, UE, other)

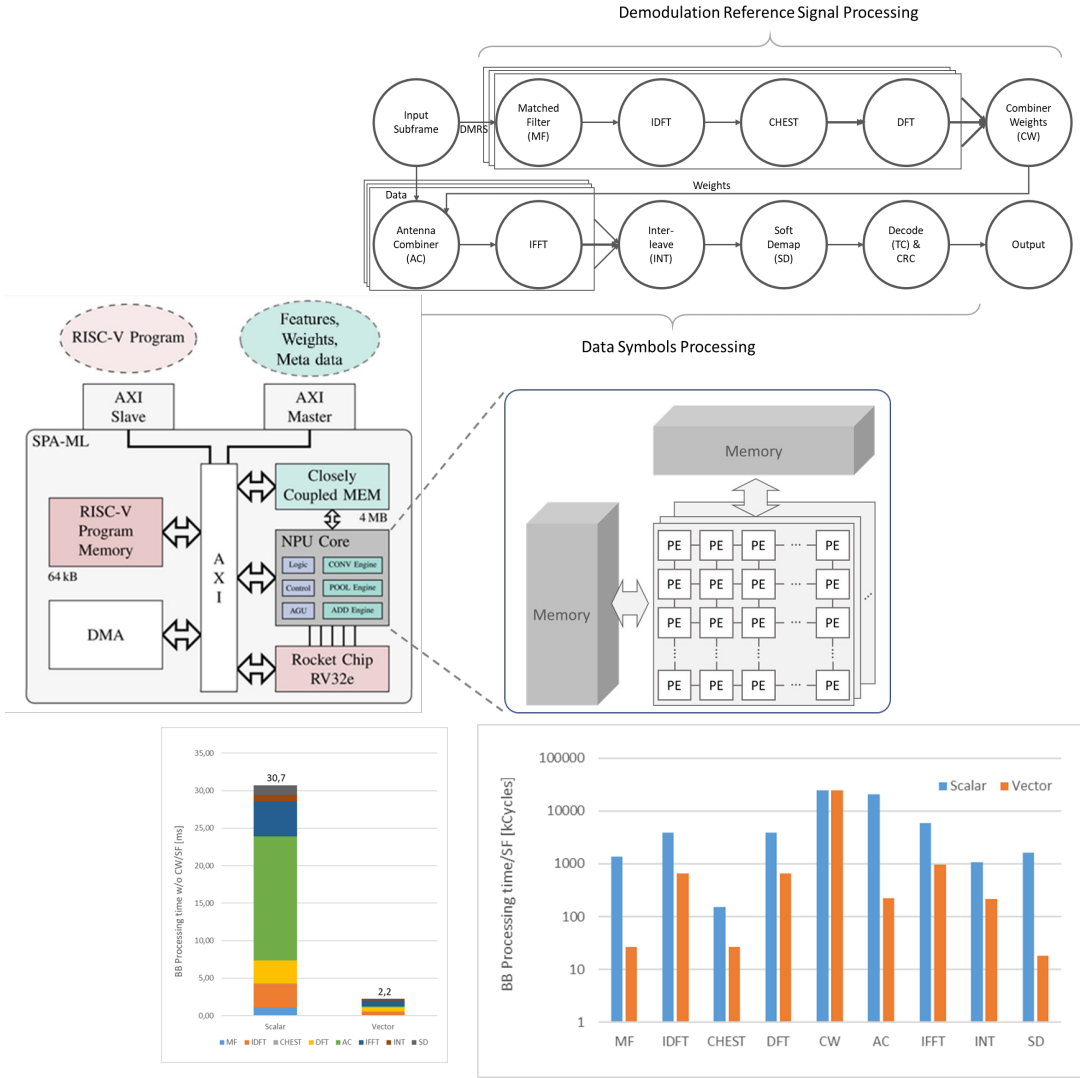


6G SoC design

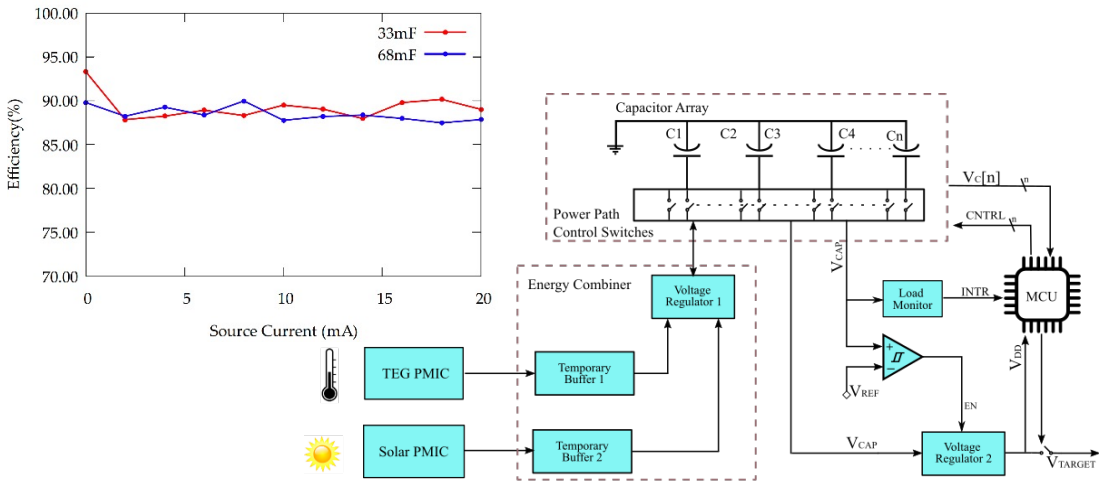
1. Secure and scalable SoC architecture tailored to a microkernel-based OS



2. DSP and AI capabilities of 6G SoC

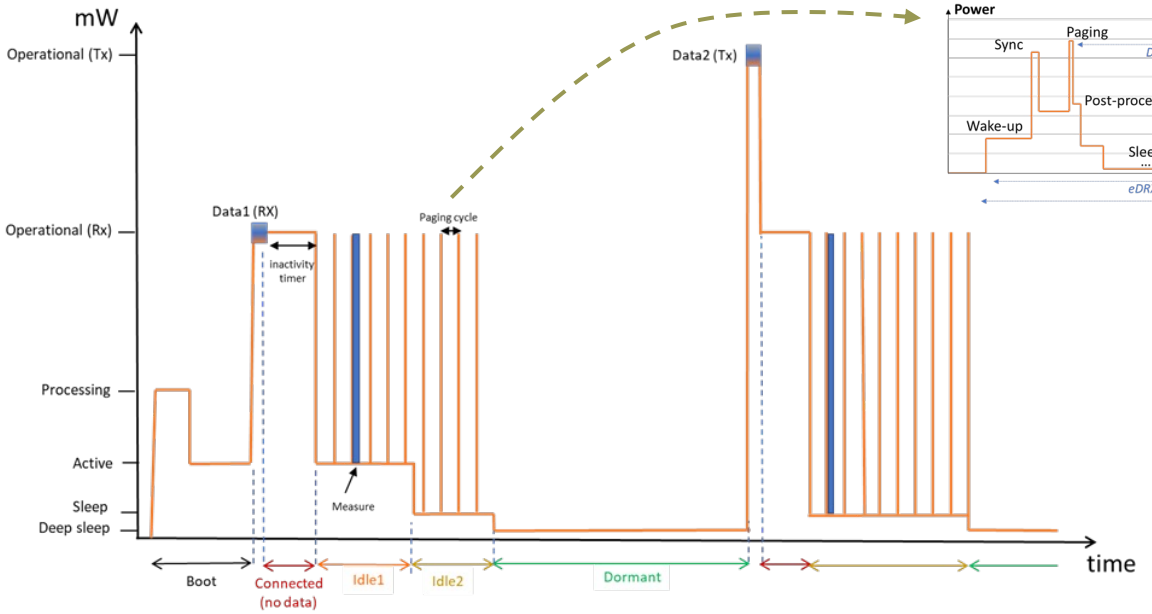


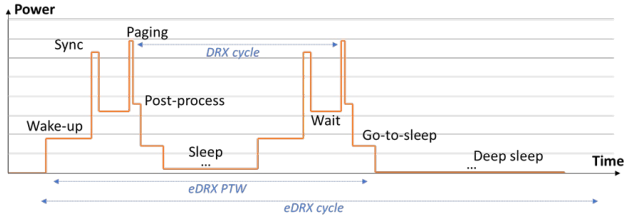
3. Multi-source energy harvesting and power management



Energy, cost, and performance trade-offs

- Power consumption analysis for 6G IoT modem
  - Obtain insight for evolution of power saving mechanisms
  - Enable battery lifetime KPI assessment (legacy and future modem)
  - Identify legacy and future potential features/mechanisms
  - Generalised parameterization for flexible analysis of future EmMTC devices or ZED

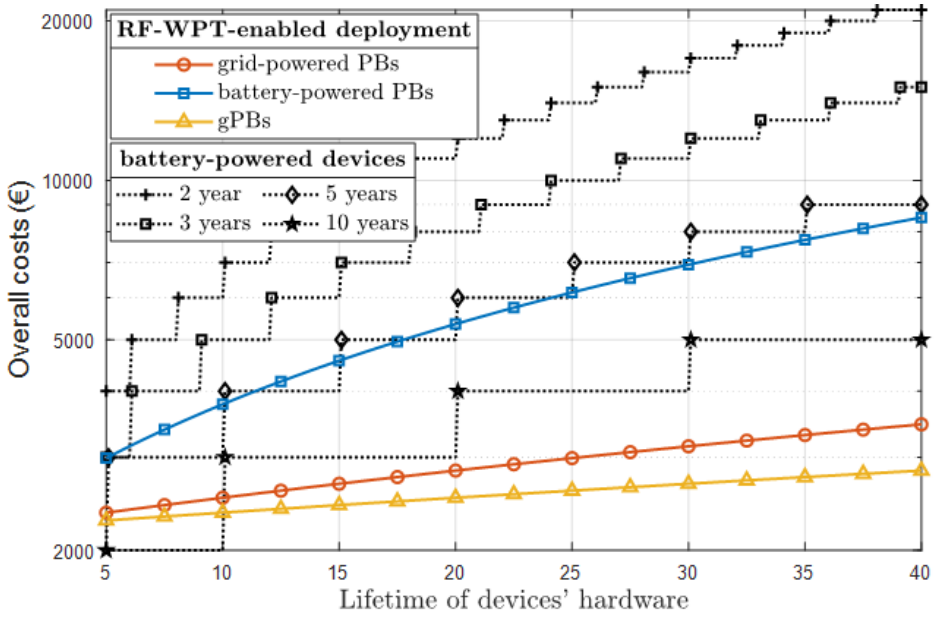




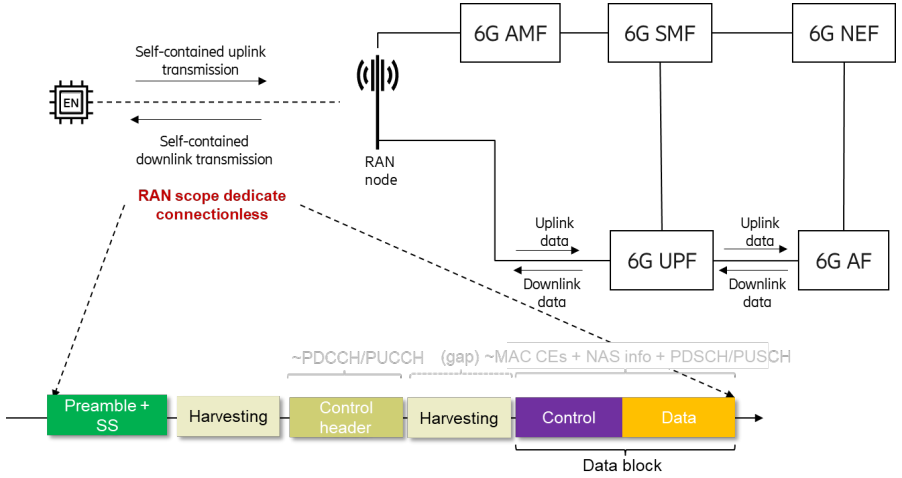
- adaptive low-power sleep modes and duty-cycling at both Tx and Rx
- adaptive energy-aware configuration for uplink and downlink transmission
- energy-aware channel access, synchronization, signaling, scheduling
- wake-up radio implementation
- advanced battery technologies, e.g., rechargeable battery storage of low self-discharge
- EH forecasting/management mechanisms
- lightweight security mechanisms
- low complexity sensing
- tiny ML for ZED targeting higher-end applications
- …

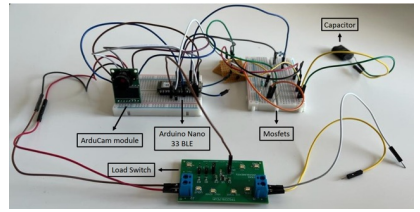
Energy neutral device technologies

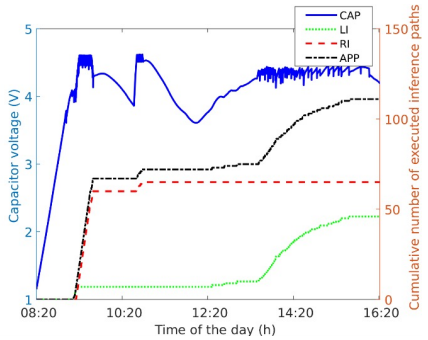
1. Trade-off analysis of RF Wireless Power Transfer (RF-WPT)
   - Power beacons for RF-WPT can be cost-effective for massive IoT



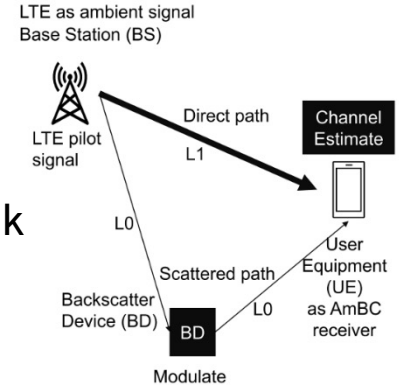
2. Energy-aware protocols & applications
   - Intelligent duty cycling and uplink/downlink scheduling
   - Secure connection-less and self-contained protocols for ambient IoT
   - Energy-aware tinyML applications that adapt ML inference to device energy



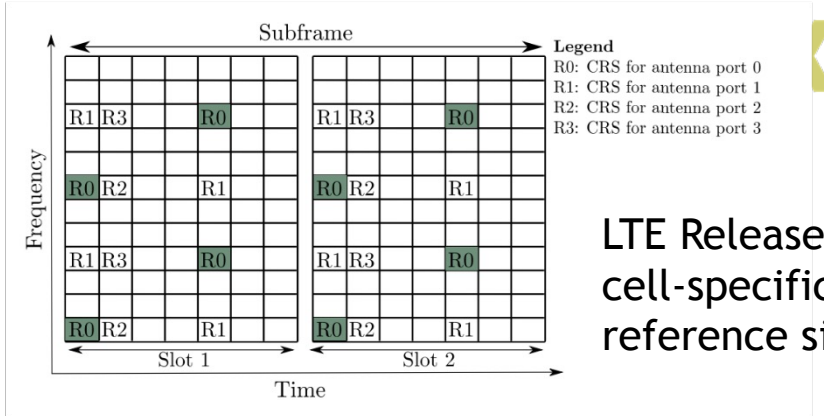




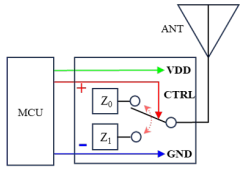
Zero Energy Device PoC



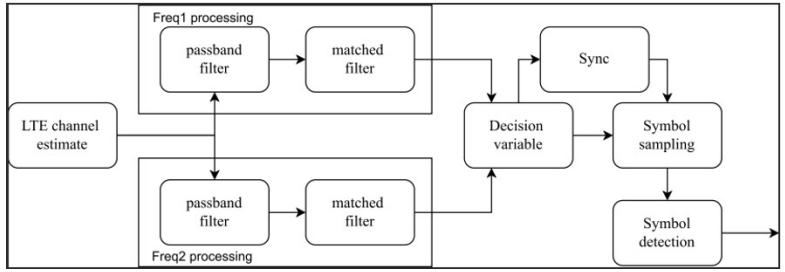
Downlink setup



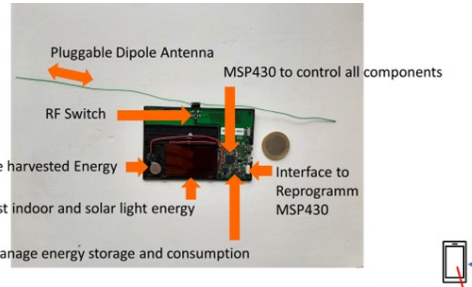
LTE Release 8 cell-specific reference signal



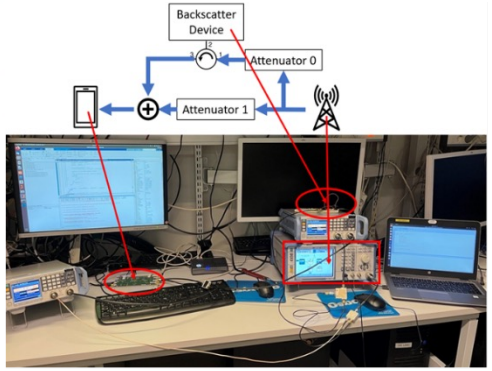
Prototype 1



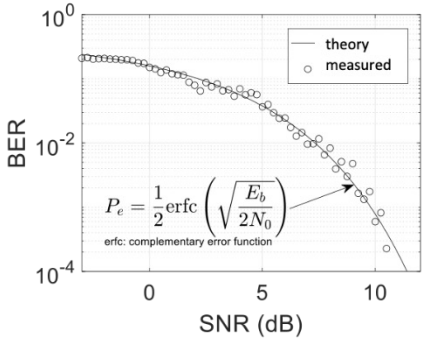
Flow chart of the proposed backscatter receiver

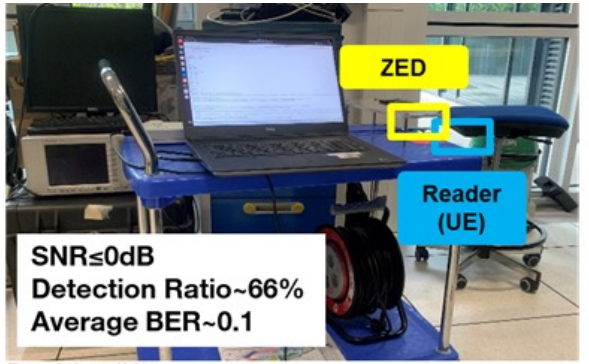


Prototype 2



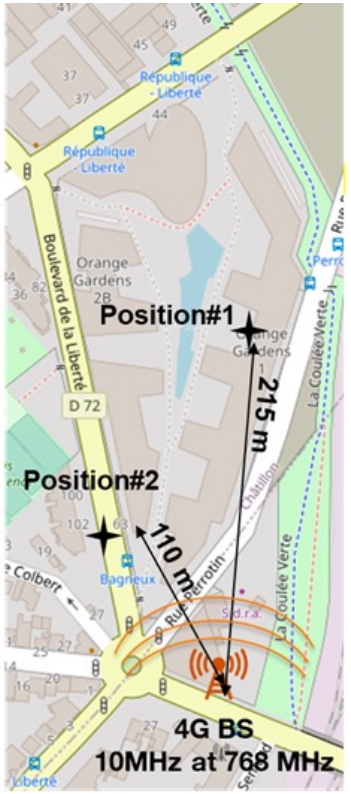
Laboratory tests





Position#1:
Non Line of Sight, Deep Indoor, Ground Floor,

Position#2:
Non Line of Sight, Deep Indoor, 4th Floor

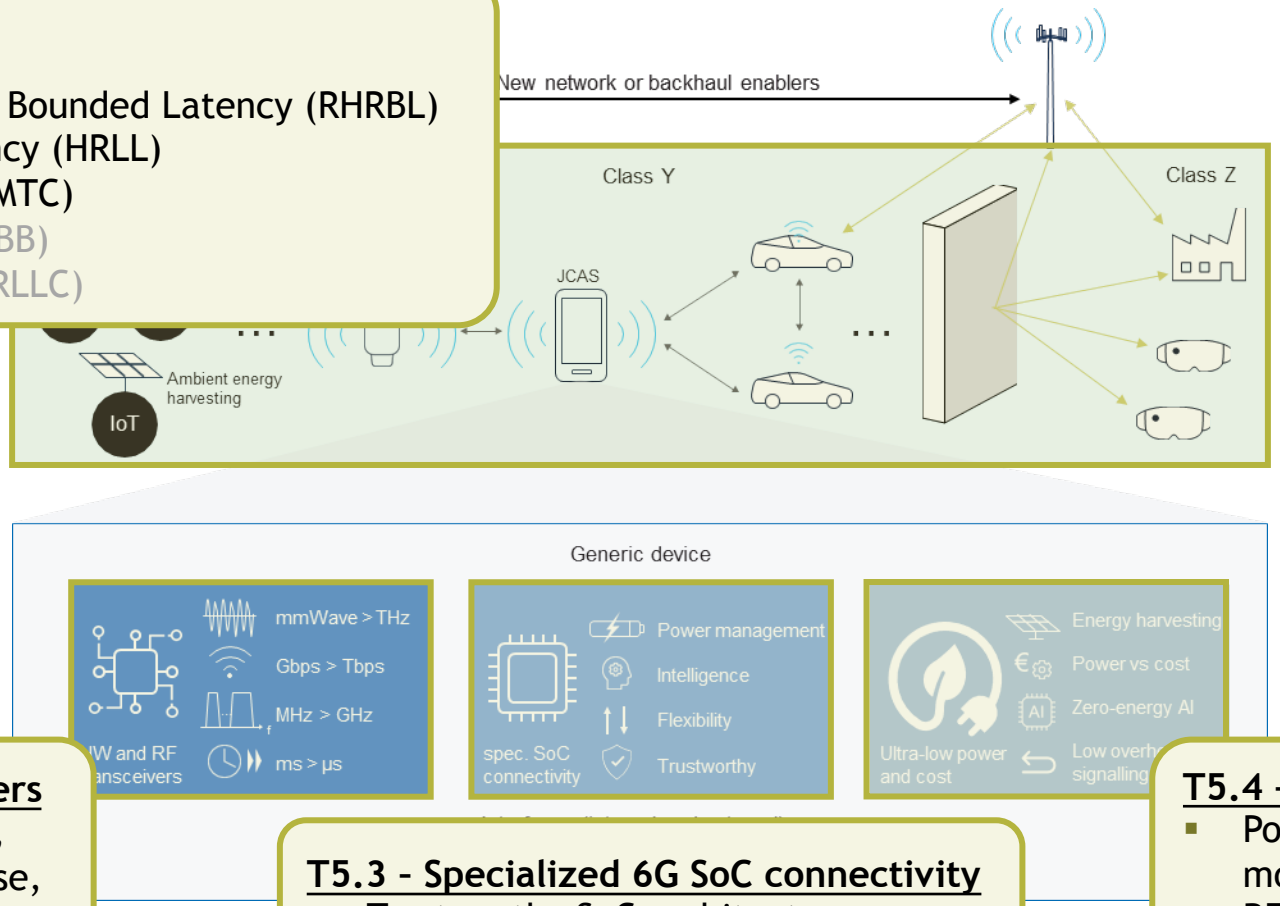


Field trial

Summary

Hexa-X-II – WP5
Future devices and flexible infrastructure

T5.1 – 6G device classes:
- Energy Neutral (EN)
- Reliable High Data Rate with Bounded Latency (RHRBL)
- High reliability and low latency (HRLL)
- Enhancements of mMTC (EmMTC)
- Enhancements of eMBB (EeMBB)
- Enhancements of URLLC (EURLLC)



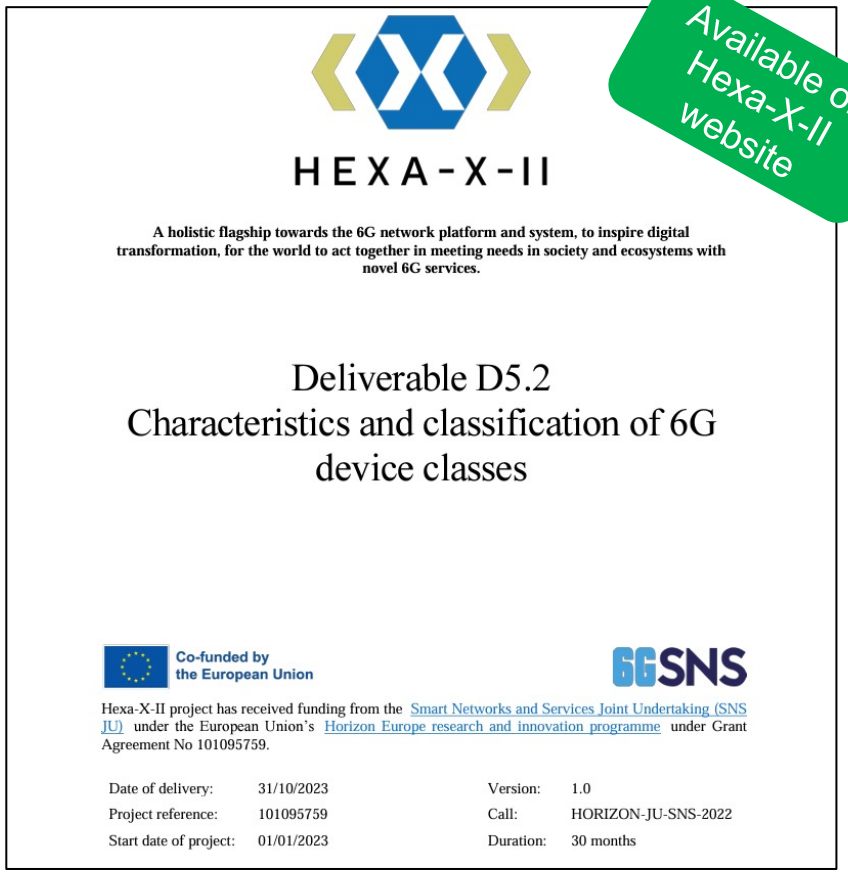
T5.2 – 6G HW and RF transceivers
- Sub-THz radio (dimensioning, HW non-idealities, phase noise, RTDs, antenna lenses)
- RIS design (reconfigurable tiles, system integration)

T5.3 – Specialized 6G SoC connectivity
- Trustworthy SoC architecture
- DSP and AI accelerators for 6G
- Multi-source energy harvesting

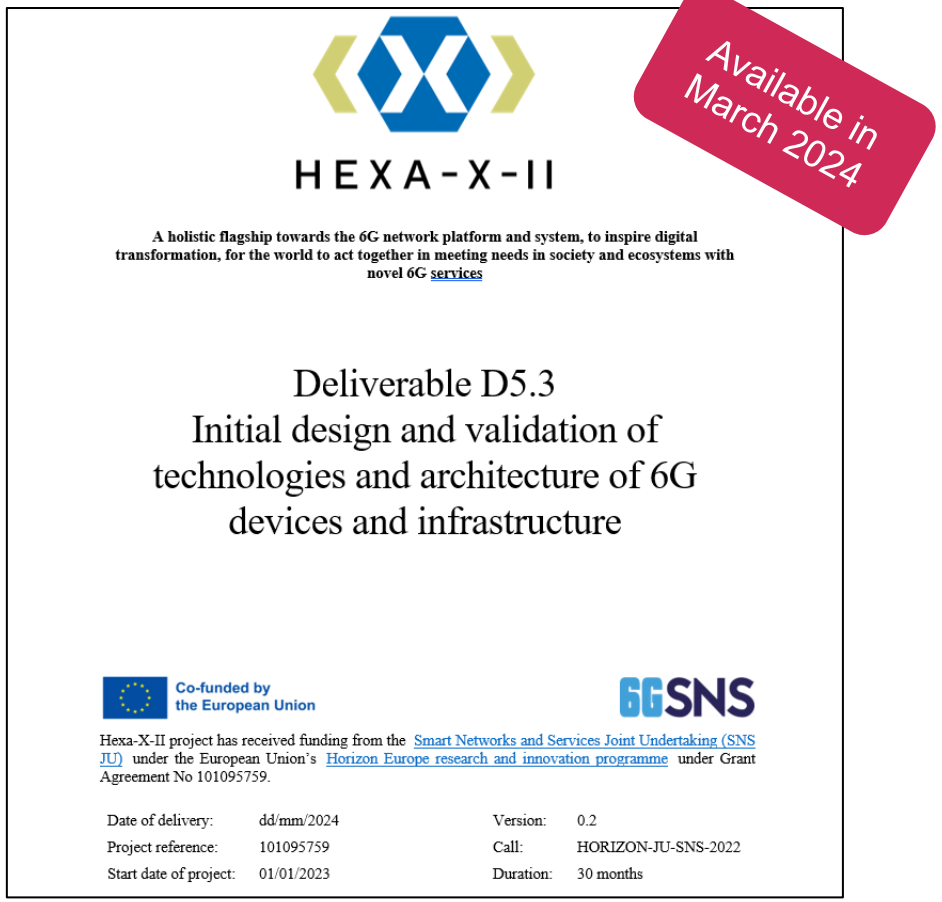
T5.4 – Ultra-low power devices
- Power consumption (IoTmodem model, cost/power trade-offs)
- RF-WPT (analysis, ambient backscatter, PoC)
- Energy-aware protocols (duty cycle, signaling overhead, tinyML)

Want to learn more about Hexa-X-II WP5?

D5.2 - Characteristics and classification of 6G device classes



D5.3 - Initial design and validation of technologies and architecture of 6G devices and infrastructure



https://hexa-x-ii.eu/deliverables/

HEXA-X-II.EU //

Co-funded by the European Union

6GSNS

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