The 6G series workshop by Hexa-X-II

Hexa-X-II: 6G Use Cases and Requirements





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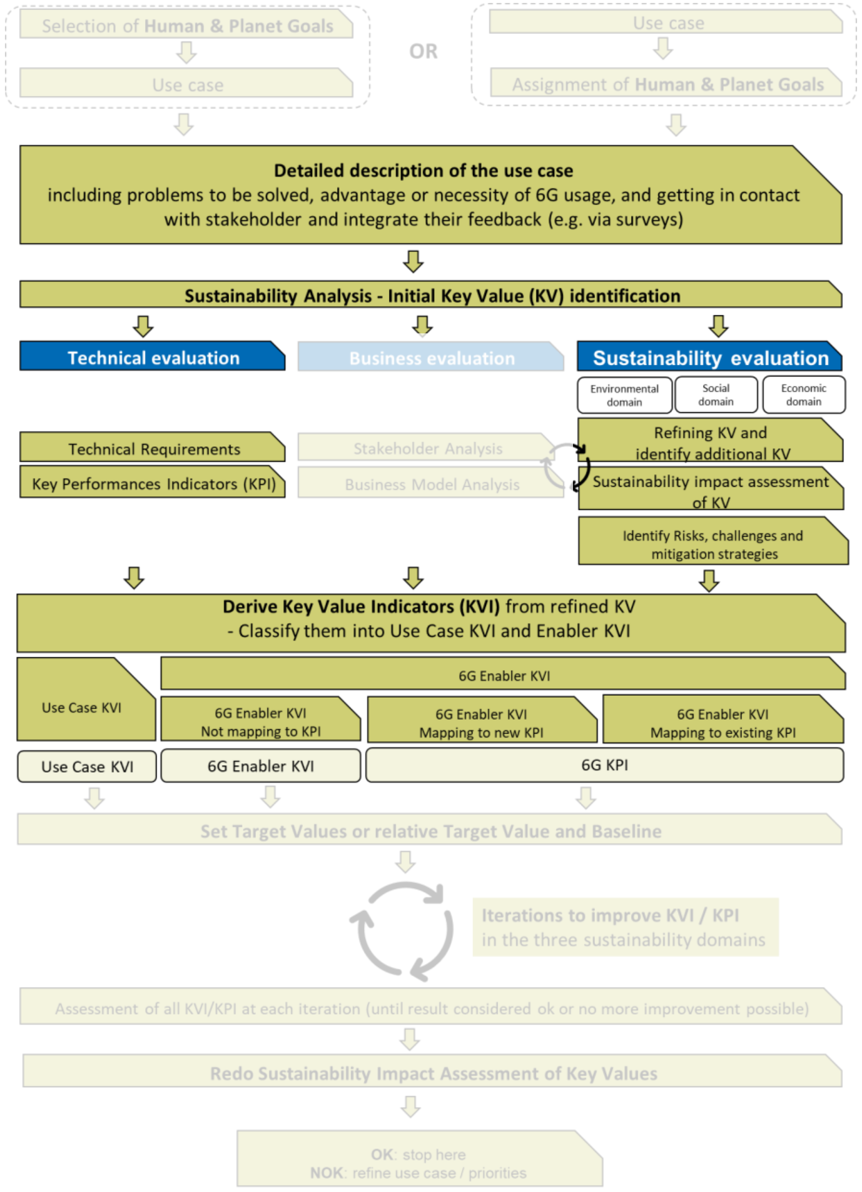
Hexa-X-II Use-case methodology



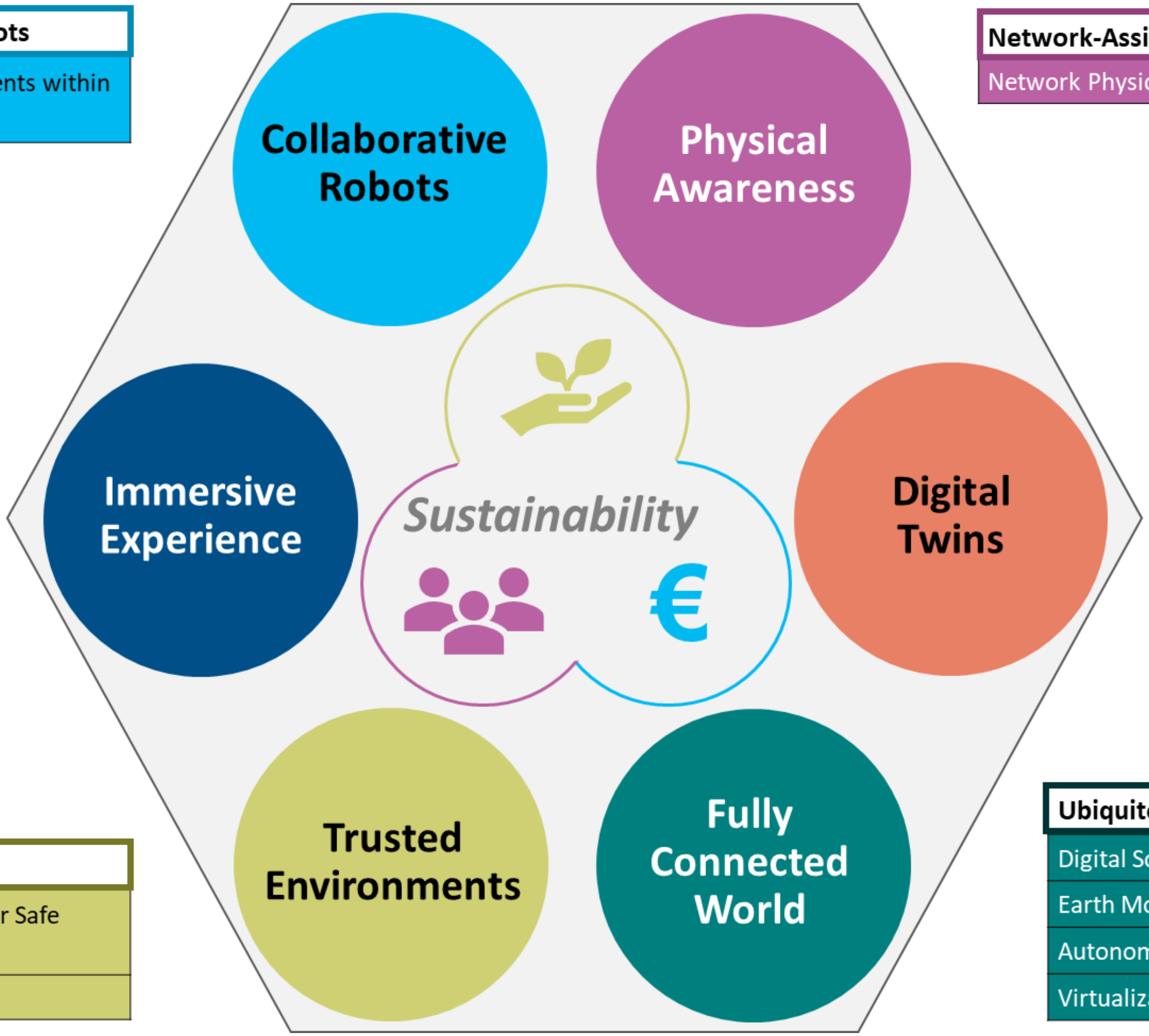
Final Set of Use Cases and Value

Hexa-X-II Use Cases

Cooperating Mobile Robots
- Autonomous Embodied Agents within Flexible Manufacturing

Network-Assisted Mobility
- Network Physical Data Exposure

Seamless Immersive Reality
- Immersive Education
- Immersive Gaming
- Live and Interactive Immersive Content Creation



Real-time Digital Twins
- Cloud Continuum
- Smart Maintenance
- Digital Twins for Construction

Human-Centric Services
- Industrial Sensors Network for Safe Production & Manufacturing
- Wireless In-Vehicle Network

Ubiquitous and Resilient Network
- Digital Sobriety and Enhanced Awareness
- Earth Monitor / Sustainable Food Production
- Autonomous Supply Chain
- Virtualization of Device Functionalities

Please note, as the IMT-2030 capability-related KPI values indicated in the following slides are formulated at an early point in time and derived from theoretical analysis and simulations, real deployments may not always fulfil these requirements. In the end, use cases will be realized if they can be delivered with acceptable cost and sustainability footprint. The feasibility of such use cases in an environmentally, socially, and economically sustainable way still needs to be evaluated beyond this project

COLLABORATIVE ROBOTS

The network's main users are machines.

Emphasis lies on task-specific local connectivity. Depending on the task or needs, the network topology may undergo frequent changes. The level of machine autonomy determines the communication requirements.

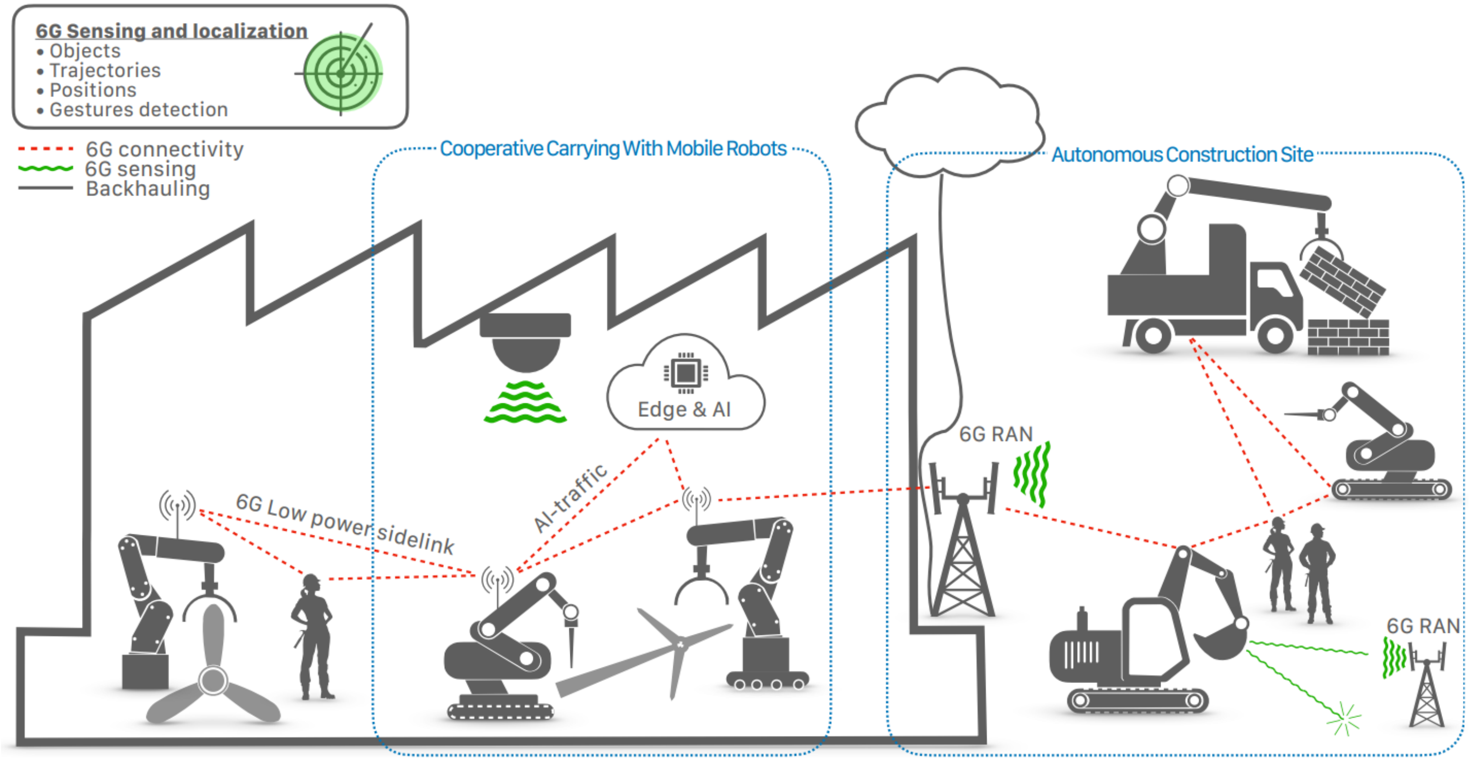
AI-generated image (Dall-E)

Use Cases

Cooperating Mobile Robots | Autonomous Embodied Agents with Flexible Manufacturing

Cooperating Mobile Robots

Collaborative Robots



Cooperating carrying with mobile robots

Robots communicate locally to perform tasks beyond their individual capabilities.

E.g., flexible manufacturing, autonomous construction site

Lot size 1

Producing bespoke products rather than in batches.

Cooperating Mobile Robots [Extract]

Functional Requirements

- Local Connectivity
- Dynamic topologies
- E2E Latency
- Positioning
- Sensing
- AI/ML

KPIs

Data rates [Mb/s]	< 10 < 250	Data rate between robots and campus network, depends on level of autonomy of robots Can be significantly higher locally in a subnetwork (raw sensor data, ML-related traffic, video stream)
D2D Latency (one way) [ms]	≤ 5 ≥ 0.8	Critical: exchange of coordination messages and control messages up to 600 times per second. Note, this results in a transfer interval of ca. 1.66 [ms]. E2E latency limit is set to at most half that interval. This provides enough margin for ARQ.
Connection density [devices/m²]	< 0.1	World's largest industrial manufacturing campuses accommodate thousands of robots. 1 m² per robot, 10% of the overall area occupied
Mobility [km/h]	< 20	Slow vehicular
D2D Latency [ms]	< 0.8	200 coordination messages per second, x3 for redundancy Transfer interval of 1.67 ms x0.5 to ensure enough margin for error recovery [22.104]

Cooperating Mobile Robots | KV/KVI analysis [Extract]

Collaborative Robots

SP	H/F	KV	KVIs (EKVI & UCKVI)	HPG	SDG
Environmental	Sustainability Handprint	Resource efficiency: Functionalities may be provided by machines with less materials, energy, and waste generated	1. Overall GHG footprint of the materials involved [tCO_2e] 2. Virgin materials (in) [tons]/Material used in products (out) [tons] 3. % of produced products remaining in stock/not possible to sell/scrapped **4. Energy consumption per process/overall [MWh]**	4, 5	6, 12, 14, 15
Environmental	Sustainability Handprint	Function integration eliminates the need for multiple dedicated machines with individual functions	1. # of different dedicated machines in a production plant 2. downtime of robot while switching functionality 3. # of functions a robot can undertake	4	6, 12
Environmental	Sustainability Footprint	Energy is consumed and materials are used to manufacture, deploy, and operate robots and associated services	1. Energy usage related to cobots through their life cycle [MWh] 1a. Energy used in manufacturing components [MWh] 1b. Energy used in transportation processes [MWh] **1c. Energy used in operation phase [MWh]** **1d. Energy used in data transfer (optimising packets and volume of data) [MWh]** 1e. Energy used in end-of-life phase [MWh] 2. Emissions related to energy usage in all previous KVIs [tCO_2e] 3. Environmental footprint related to materials usage, across the life-cycle 4. Material usage of cobots, across their life-cycle [tons, total footprint] **5. 'Data efficiency' on storage [Terabytes]**	3, 4	6, 12, 13
Environmental	Sustainability Footprint	The manufacturing, including material extraction and industrial processes, and transportation of robots generate GHG emissions	**1. Total life-cycle emissions [tCO_2e]** **2. Share of recycled or reused materials used [%]** **3. Materials used after/Materials used before [%]**	3	13
Environmental	Sustainability Footprint	The disposal of machines and devices results in increased electronic waste	**1. Life expectancy of robots [unit of time]** 2. % of recyclability of robots **3. # of virtualized functionalities** 4. Weight of e-waste [tons] 5. Weight of e-waste properly recovered/reused/ recycled [tons]	5	12, 14, 15
Social	SF&SH	...	...	...	...
Economic	SF&SH	...	...	...	...

- The table on the **left**, shows an extract for only the environmental aspects on the KVs identified for the Cooperating Mobile Robots' (CMR) use case, and their related KVIs.
- Those KVIs which have the potential to be influenced through technical design, are highlighted as **Enabler KVIs (EKVI)**.
- These were then grouped into categories and value requirements and linked to technical requirements for subsequent evaluation by WP2, as shown in the table **below**.

- D1.4 contains the complete table, displaying also the social and economic impacts.
- It must be noted that the process of establishment of Key Values and Key Values Indicators remains a subjective process and requires the involvement of all stakeholders

Categories	Value Requirements	Example EKVIs	Technical Requirements
Energy	Minimise the energy usage for the correct operation of robots, both on communication links and in the data processing, data storage, and data collection aspects.	• Energy consumption per process/overall [MWh] • Energy used in operation phase [MWh] • Energy used in data transfer (optimising packets and volume of data) [MWh] • 'Data efficiency' on storage [TB]	• Energy-efficient Network operation • Energy neutral devices • Energy-efficient AI/ML training and inference
Materials/ Waste	Reduce material dependency, foster longer-lasting materials/products, use materials where it is really necessary, choose materials with lower environmental impact, etc. The latter spans from infrastructure-related materials to operational aspects, where 6G-related services can have an impact.	• Total life-cycle emissions [tCO_2e] • Share of recycled or reused materials used [%] • Materials used after/Materials used before [%] • Life expectancy of robots [unit of time] • # of virtualised functionalities	• Modularization • Virtualization • Softwarization • Compute offloading • Resilience • Predictable Low-latency
Safety	...	...	...
Trustworthiness/ Privacy/Security	...	...	...
Costs	...	...	...
Productivity / Efficiency	...	...	...

Thank you for your attention

EUCNC presentations on the same framework

Tuesday 3/6/25

Workshop 2: The 6G series workshop by Hexa-X-II

11h-11h15: Hexa-X-II: 6G use cases and requirements

Workshop 18: Technology Enablers for Sustainable 6G Design

16h15-16h25: 6G E2E sustainable system design using knowledge graph

Wednesday 4/6/25

Special Session 7: Social Acceptance as a Catalyst for Sustainable 6G

16h08-16h15: Anchoring 6G in Society: Approaches and intervention points to promote social acceptance

Thursday 4/6/25

Special Session 17: - Value Approach of 6G: The Role of Key Value Indicators in Design and Societal Impact

11h07-11h18: Bringing KVIs for societal impact, shaping them, and future work to come

Hexa-X-II – Deliverable D1.4

https://hexa-x-ii.eu/wp-content/uploads/2025/05/D1.4-final.pdf

More information on hexa.x.ii.eu

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6GSNS

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