HEXA-X-II

Drivers for 6G and update on Key Value Indicators (KVI)

Stefan Wendt - Orange

Hexa-X-II Principles and Use Cases

Design 6G to deliver value and to be sustainable

Sustainability is the key value and driver in Hexa-X-II, encompassing the three pillars…

- Environmental sustainability
- Social sustainability (incl. Trustworthiness and inclusion)
- Economic sustainability

… the duality

- **Sustainable 6G**: 6G should be inherently designed to meet sustainability commitments (NetZero,…)
- **6G for sustainability**: 6G-based services enabling other sectors/verticals to minimize their impact

… and involve society

- Obtain **feedback on 6G value** addressing their needs and concerns

to define use cases and requirements

- Extract **requirements**, **Key Performance Indicators** and **Key Values and Indicators**

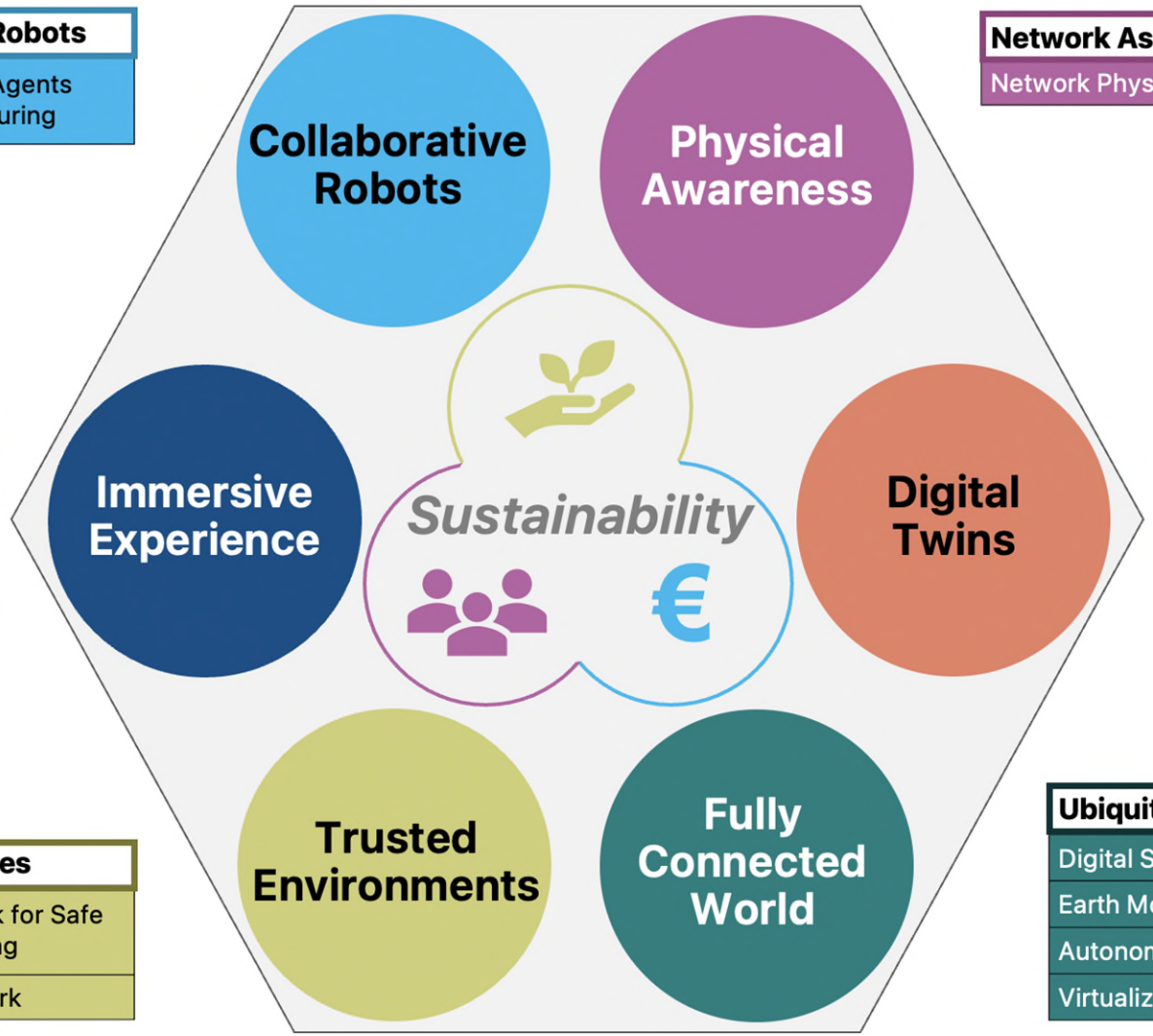
and analyse stakeholders & ecosystem models

- Identify key **stakeholders** and define **business and revenue models** and establish the **6G ecosystem**

Hexa-X-II Use Case Families

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

Realtime Digital Twins
- Cloud Continuum
- Smart Maintenance
- Digital Twins (Building Model)

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

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

Hexa-X-II Use Cases with **Highlighted** Representative Use Cases

Hexa-X-II process

Use Case and Sustainability Analysis

WP1 - Use Cases & Sustainability Analysis

Hexa-X-II « should be » situation

Selection of Human & Planetary Goals

Use case

Use case

Assignment of Human & Planetary Goals

Very often « as is » situation

Description (of the use case)

Problem(s) to be Solved/Challenges (for the use case)

Why 6G ?

Surveys and feedback from external stakeholders

Sustainability Analysis - Initial Key Value (KV) identification (related to Handprints/Footprints)

Technical evaluation

Technical Requirements

Key Performances Indicators (KPI)

Business evaluation

Stakeholder Analysis

Business Model Analysis

Sustainability evaluation

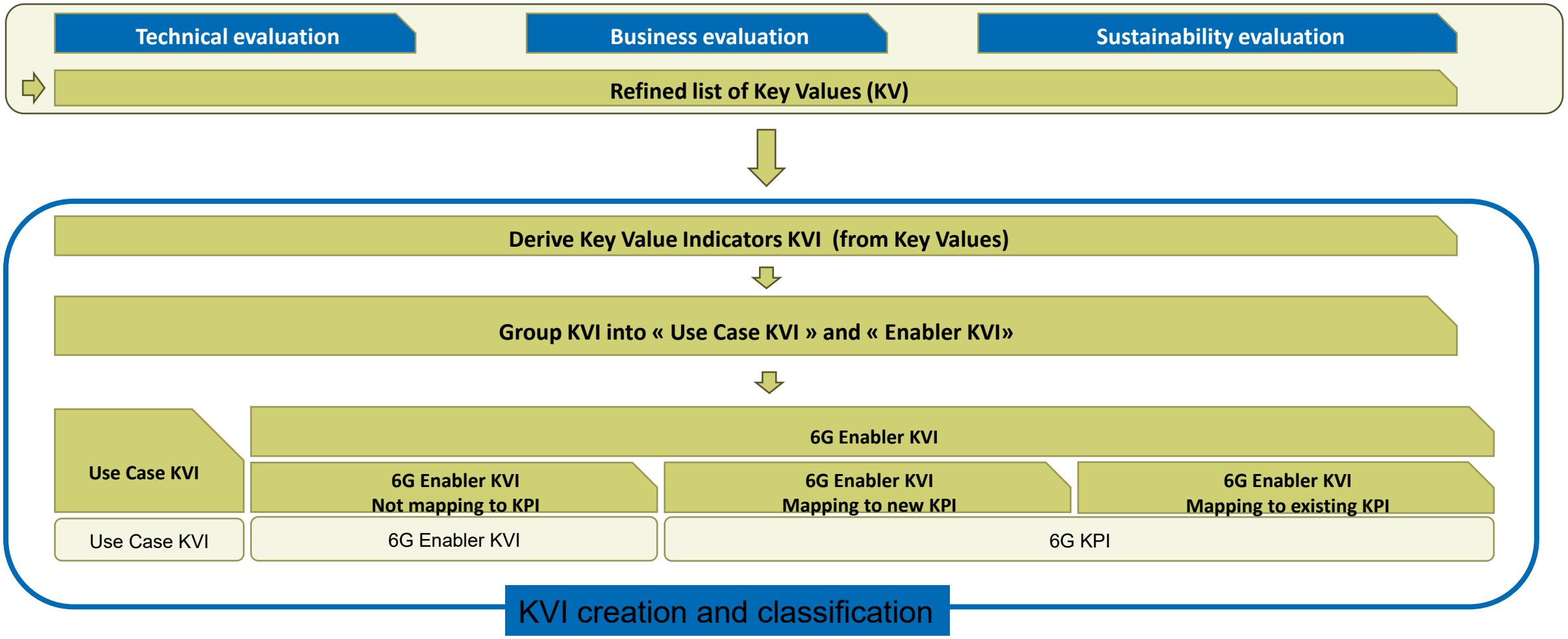
Environmental domain | Social domain | Economic domain

Refining KV & additional KV

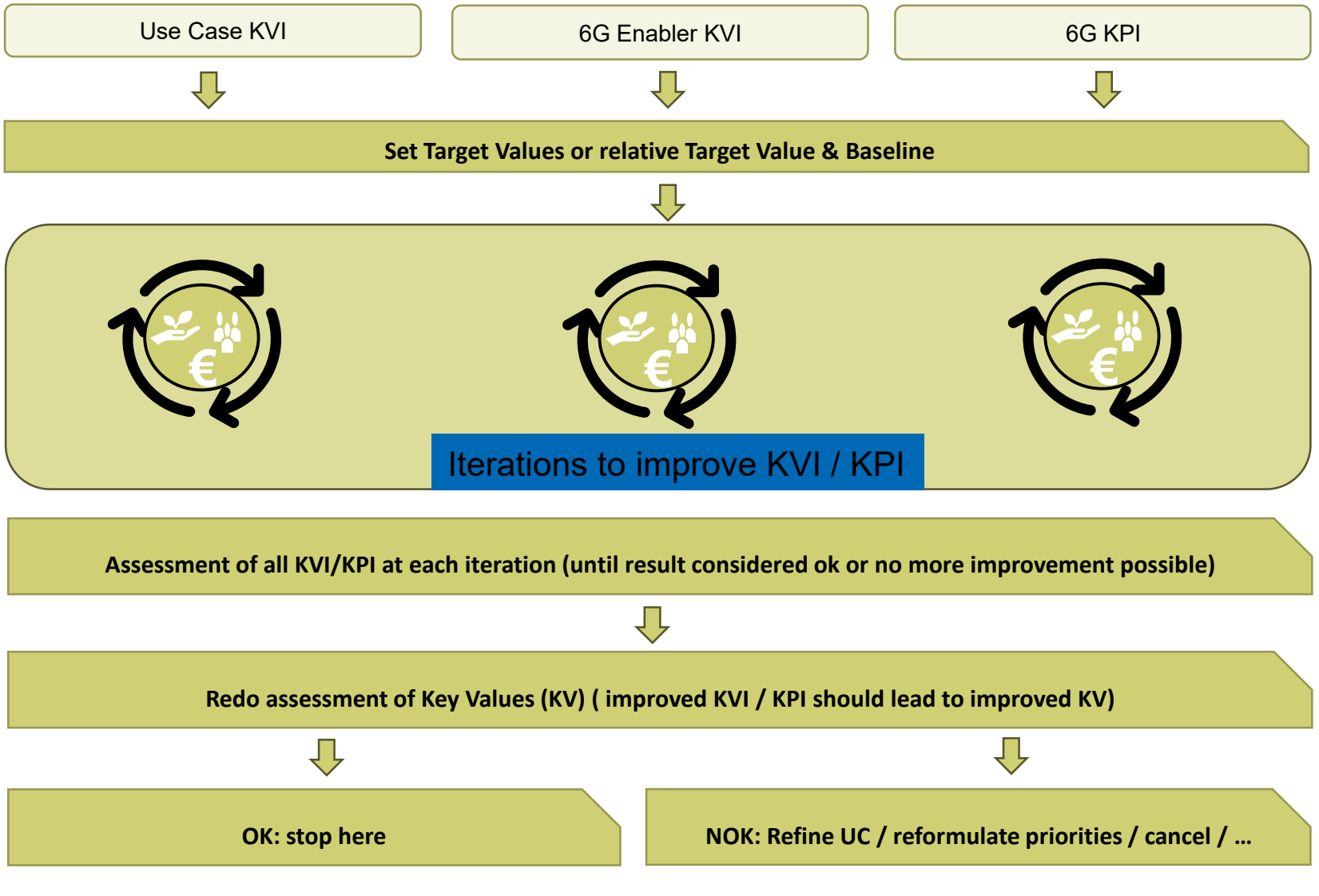
Sustainability impact Assessment of Key Value (Handprints/Footprints)

Risks, challenges and mitigation & identifying main categories for further impact analysis

WP1 – Use Cases & Sustainability Analysis



WP1 – Use Cases & Sustainability Analysis



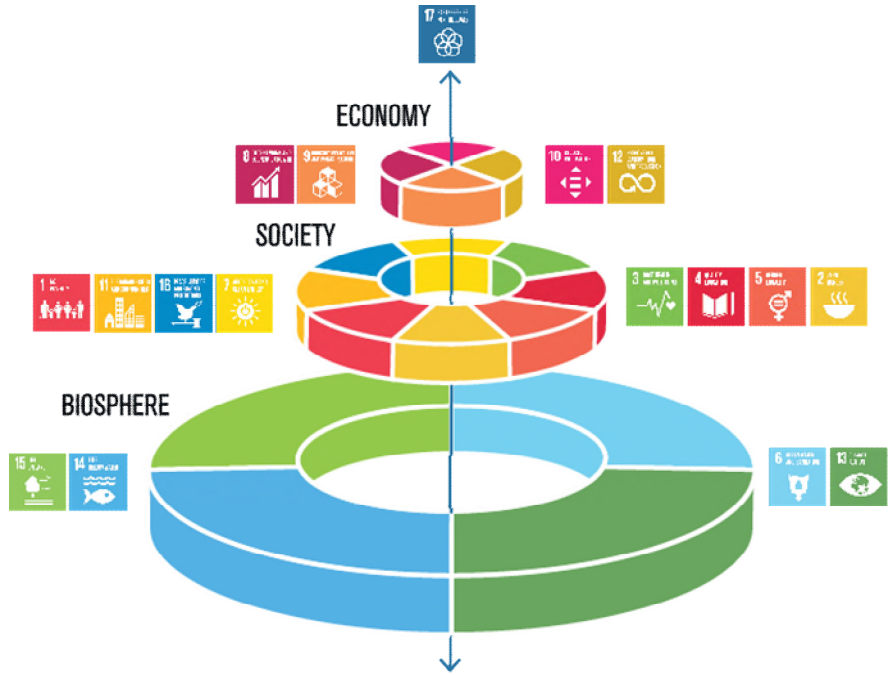
Not done in Hexa-X-II

Goals, Key Values & Key Value Indicators

Overview

A new starting point introduced
High Level Human and Planetary Goals

- New technology should support a more sustainable future
- A common set of goals was introduced, **The Human and Planetary Goals** **15 items list**
  - Derived from sustainability focus areas formulated in previous deliverables in Hexa-X-II – D1.1 and D1.2
  - Thoroughly discussed and formulated in the assigned working group
  - Linked to the United Nations Sustainable Development Goals



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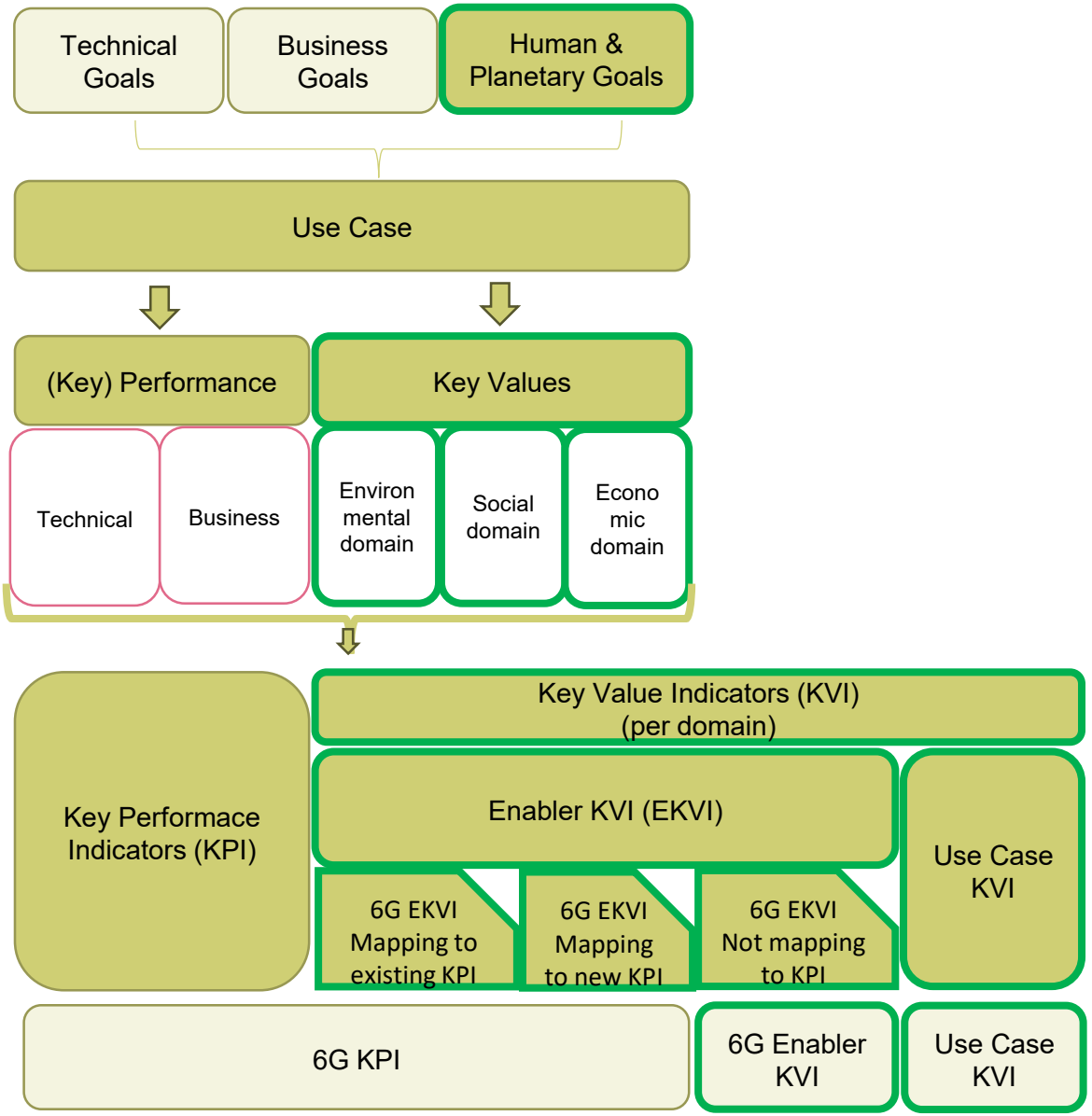
Overall Principle



Definitions	
High-level Human & Planetary Goals	High-level human values as goals, like the UN SDGs or their subsets.
Key Values	Key values represent the impact of the use case & technology on the high-level human and planetary goals. ➢ Positive impact of use case & technology use needs to be maximized, and negative impacts need to be minimized. ➢ Key Values have to be identified in the three sustainability domains.
Key Value Indicator	A KVI is a qualitative or quantitative indicator for assessing a KV. The purpose of KVI is to gauge the impact from the execution of a use case in terms of economic, social and environmental outcomes. A certain target should be set for each KVI. Two type of KVI exist: ➢**Use Case KVI**: a quantitative or qualitative indicator used to assess an impact of a use case (application) ➢**Enabler KVI**: a quantitative or qualitative indicator to assess the impact of the technical enabler, i.e. the technology applied to a Use Case.

Use Case Example

Cooperating Mobile Robots (reference) use case

Hexa-X-II Use Case Families

(more details in Hexa-X-II Deliverable D1.2)

Use Case Families

Representative Use Case

Use Cases

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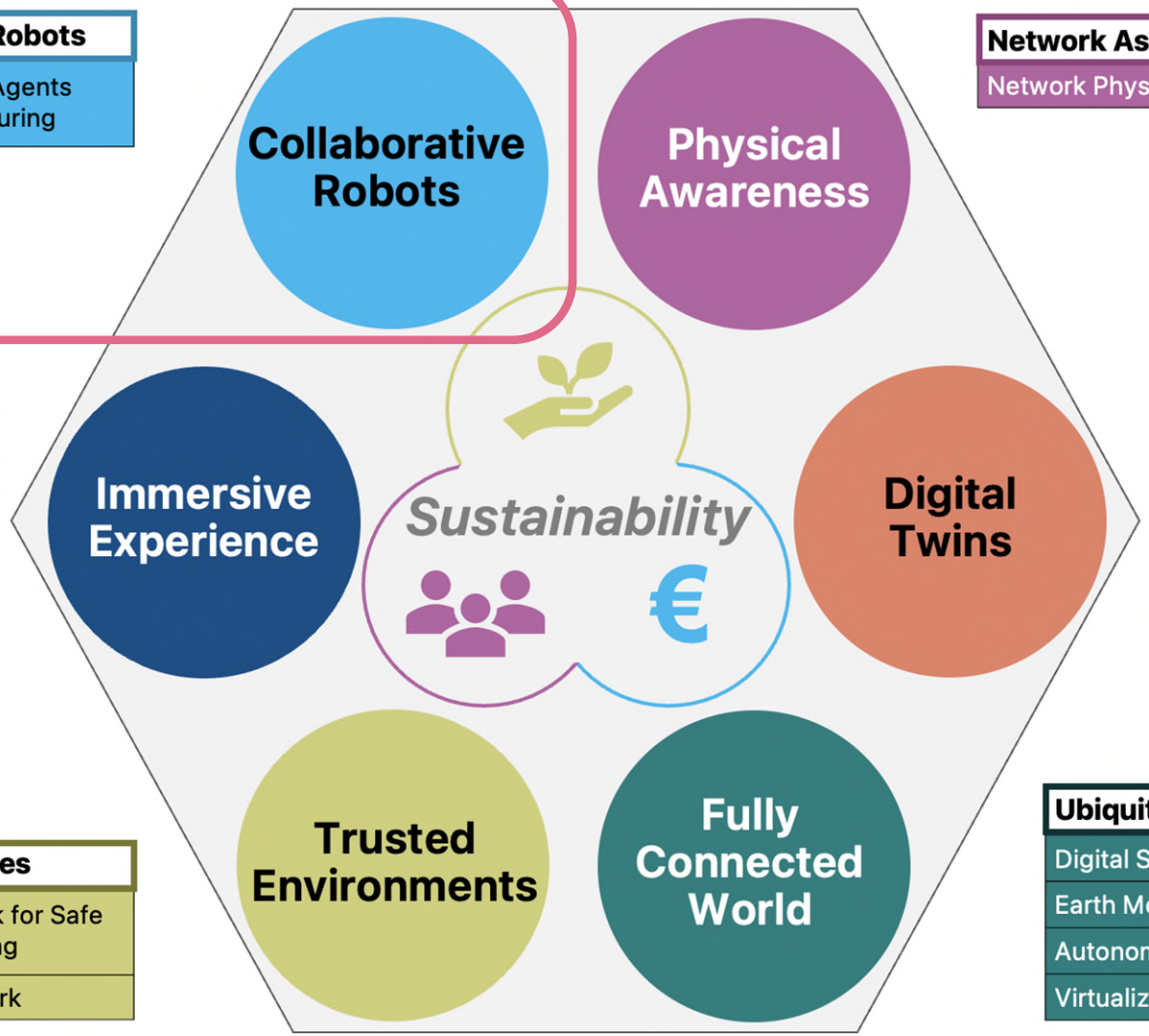

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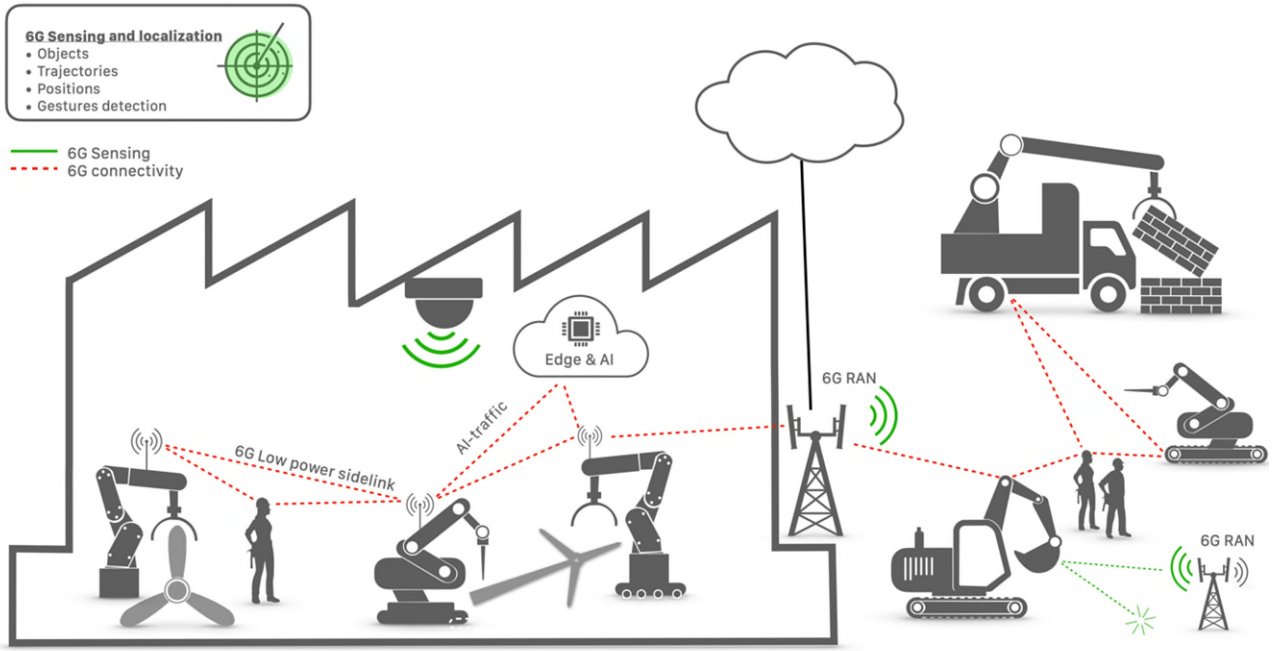
Hexa-X-II Use Cases with **Highlighted** Representative Use Cases

Cooperating Mobile Robots

Collaborative Robots



Cooperating mobile robots

Robots communicate locally to perform tasks beyond their individual capabilities.

E.g., flexible manufacturing, autonomous construction site

Autonomous embodied agents

AI/ML and integrated sensing enable tools/machines to make decisions.

Example Scenarios

- Cooperative carrying with robots
- Lot size 1 production
- Automated industrial tasks (e.g., quality checks)
- Autonomous farming
- Autonomous construction site
- Smart workshop

Problem(s) to be Solved/Challenges

- Understanding and addressing the communication requirements of machines in the future
- Using limited resources efficiently
- Adapting to dynamic requirements of the market
- End-user access to custom manufacturing
- Safe and trustworthy interactions with tools that can make decisions

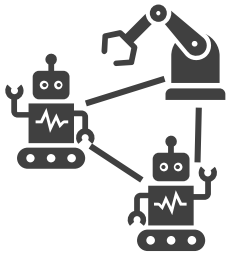
Why 6G?

- 5G URLLC does not meet the latency, reliability, and scalability requirements in demanding scenarios.
- Benefit greatly from advances in ML, and network-side support (e.g., training, offloading, edge computing)
- Sensing and positioning capabilities to enrich advanced ML applications

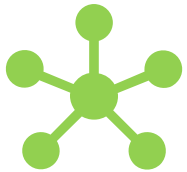
Cooperating Mobile Robots

Collaborative Robots

Functional Requirements



Local Connectivity



Dynamic topologies

E2E Latency

Positioning

Sensing

AI/ML

KPIs

Data rates [Mb/s]	< 10	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)
Area density [Mb/s/m²]	< 0.1	World's largest industrial manufacturing campuses accommodate thousands of robots. 1 m² per robot, 10% of the overall area occupied
Mobility	< 20	Slow vehicular
E2E 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]
Reliability [%]	99.999 – 99.99999	Application-side mechanism compensate occasional packet losses and delays at link level ("survival time") Selected applications may have an even more strict reliability requirement up to 99.999999% [22.104].

Cooperating Mobile Robots - High-level Human and Planetary Goals

Collaborative Robots

Goals

Environmental Sustainability

Selected out of Hexa-X-II 15 items list

Human and Planetary Goals	Related UNSDGs
Minimize Waste Preserve natural resources	12, 14, 15 6, 12
Preserve natural resources	6, 12
Curb Climate Change Preserve natural resources	13 6, 12
Curb Climate Change	13
Minimize Waste	12, 14, 15

Social Sustainability

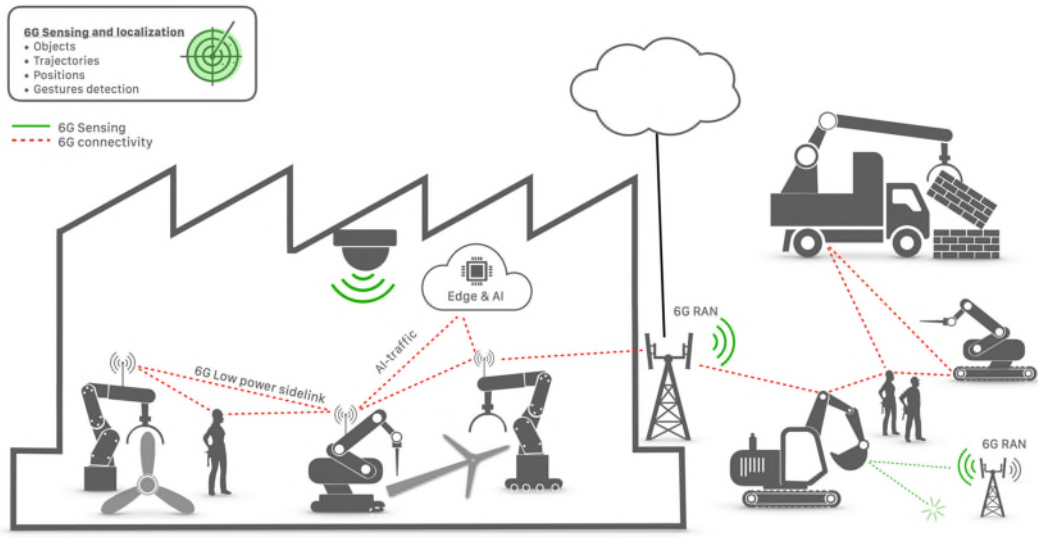
Human and Planetary Goals	Related UNSDGs
…	…

Economic Sustainability

Human and Planetary Goals	Related UNSDGs
…	…

Cooperating Mobile Robots – Key Values

Collaborative Robots



Definition

Key values represent the impact of the use case & technology on the high-level human and planetary goals.

- Positive impact of use case & technology use needs to be maximized, and negative impacts need to be minimized.
- **Key Values have to be identified in the three sustainability domains**.

Goals

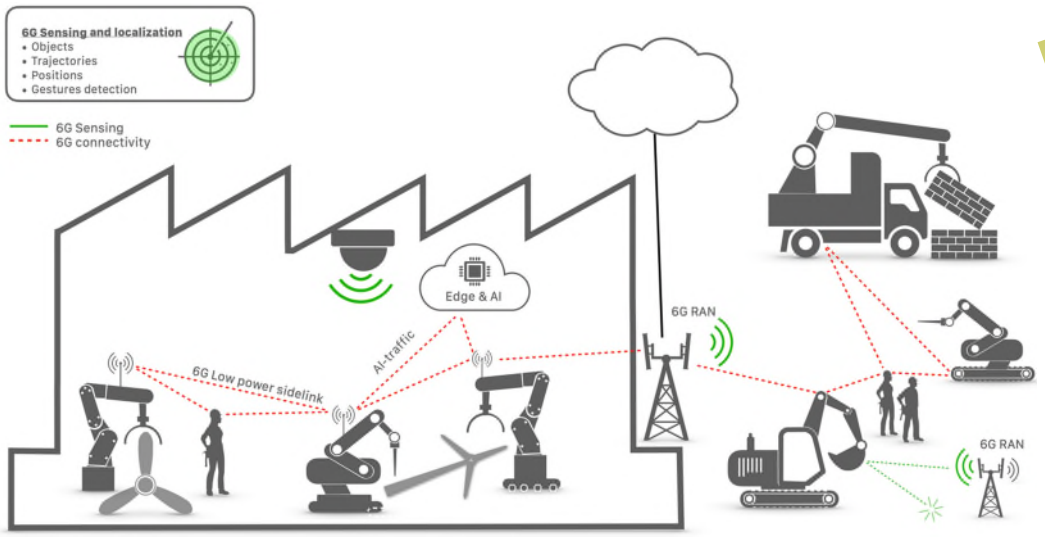
Key Values

	Handprints (benefits)	Footprints (costs)
Environmental Sustainability	• Increased efficiency in production processes • Reduced need for multiple machines due to function integration	• Increased material and energy consumption throughout full life cycle of the robots and associated services • Increased electronic waste
Social Sustainability	• Improved accessibility from tasks beyond human capabilities • Safer working environments • M2H support	• Elimination of jobs • Uneven distribution of benefits from robots and cobots • Unauthorized use of sensors and associated privacy concerns
Economic Sustainability	• Enhanced productivity and competitiveness • New business and job opportunities	• Barriers for small businesses • Monopolization risks • Financial loss in case of service failure or cyber-attacks

non-exhaustive list

Cooperating Mobile Robots - Key Value Indicators (Environment)

Collaborative Robots



Definition

A Key Value Indicator (KVI) is a qualitative or quantitative indicator for assessing a Key Value.

Two type of KVI exist:
➢**Use Case KVI**: a quantitative or qualitative indicator used to assess **an impact of a use case** (application)
➢**Enabler KVI**: a quantitative or qualitative indicator to assess **the impact of the technical enabler, i.e. the technology** applied to a Use Case.

non-exhaustive list

		Key Values Indicators	
		Key Value	**KVI**
Environmental Sustainability	**Sustainability Handprint**	Resource efficiency: Functionalities may be provided by machines with less materials, energy, and waste generated	Overall footprint of the materials involved
			Raw materials_in [Tons]/Material used in products_out [Tons]
			% of produced products remaining in stock/not possible to sell/scrapped
			kWh per process/overall
		Function integration eliminates the need for multiple dedicated machines with individual functions	# of different dedicated machines in a production plant
			downtime of robot while switching functionality
			# of functions a robot can undertake
	Sustainability footprint	Energy is consumed and materials are used to manufacture, deploy, and operate robots and associated services	Energy usage to produce robot's components
			Overall footprint of the materials involved in manufacturing
			Energy usage per robot in operation phase
			Energy usage for data transfer (optimising packets and amount of data)
		The manufacturing, including material extraction and industrial processes, and transportation of robots generate GHG emissions	Total footprint of production & transportation processes
			% share of recycled materials used
			% material reduction (kg or GHG)
		The disposal of machines and devices results in increased electronic waste	life expectancy of robots
			% of recyclability of robots
			% of reused materials used
			# of virtualised functionalities

Cooperating Mobile Robots – Goals and Outcomes

Not exhaustive

Collaborative Robots

Example

		Goals			Outcome		
		Related UNSDGs	Human and planetary goals	Key Value	KVI	UCKVI	EKVI
Environmental Sustainability	Sustainability Handprint	12, 14, 15 6, 12	Minimize Waste Preserve natural resources	Resource efficiency: Functionalities may be provided by machines with less materials, energy, and waste generated	Overall footprint of the materials involved	Y	
					Raw materials_in [Tons]/Material used in products_out [Tons]	Y	
					% of produced products remaining in stock/not possible to sell/scrapped	Y	
					kWh per process/overall	Y	Y
		6, 12	Preserve natural resources	Function integration eliminates the need for multiple dedicated machines with individual functions	# of different dedicated machines in a production plant	Y	
					downtime of robot while switching functionality		Y
					# of functions a robot can undertake	Y	
	Sustainability footprint	13 6, 12	Curb Climate Change Preserve natural resources	Energy is consumed and materials are used to manufacture, deploy, and operate robots and associated services	Energy usage to produce robot's components	Y	
					Overall footprint of the materials involved in manufacturing	Y	
					Energy usage per robot in operation phase	Y	Y
					Energy usage for data transfer (optimising packets and amount of data)		Y
		13	Curb Climate Change	The manufacturing, including material extraction and industrial processes, and transportation of robots generate GHG emissions	Total footprint of production & transportation processes	Y	
					% share of recycled materials used	Y	
					% material reduction (kg or GHG)	Y	
		12, 14, 15	Minimize Waste	The disposal of machines and devices results in increased electronic waste	life expectancy of robots	Y	
					% of recyclability of robots	Y	
					% of reused materials used	Y	
					# of virtualised functionalities		Y

HEXA-X-II

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Co-funded by the European Union

6GSNS

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