ITU-ETSI Symposium on ICT Sustainability –

Standards Driving Environmental Innovation.

11-12 December 2024

The Hexa-X-II project - How is Sustainability a central design principle for 6G ?

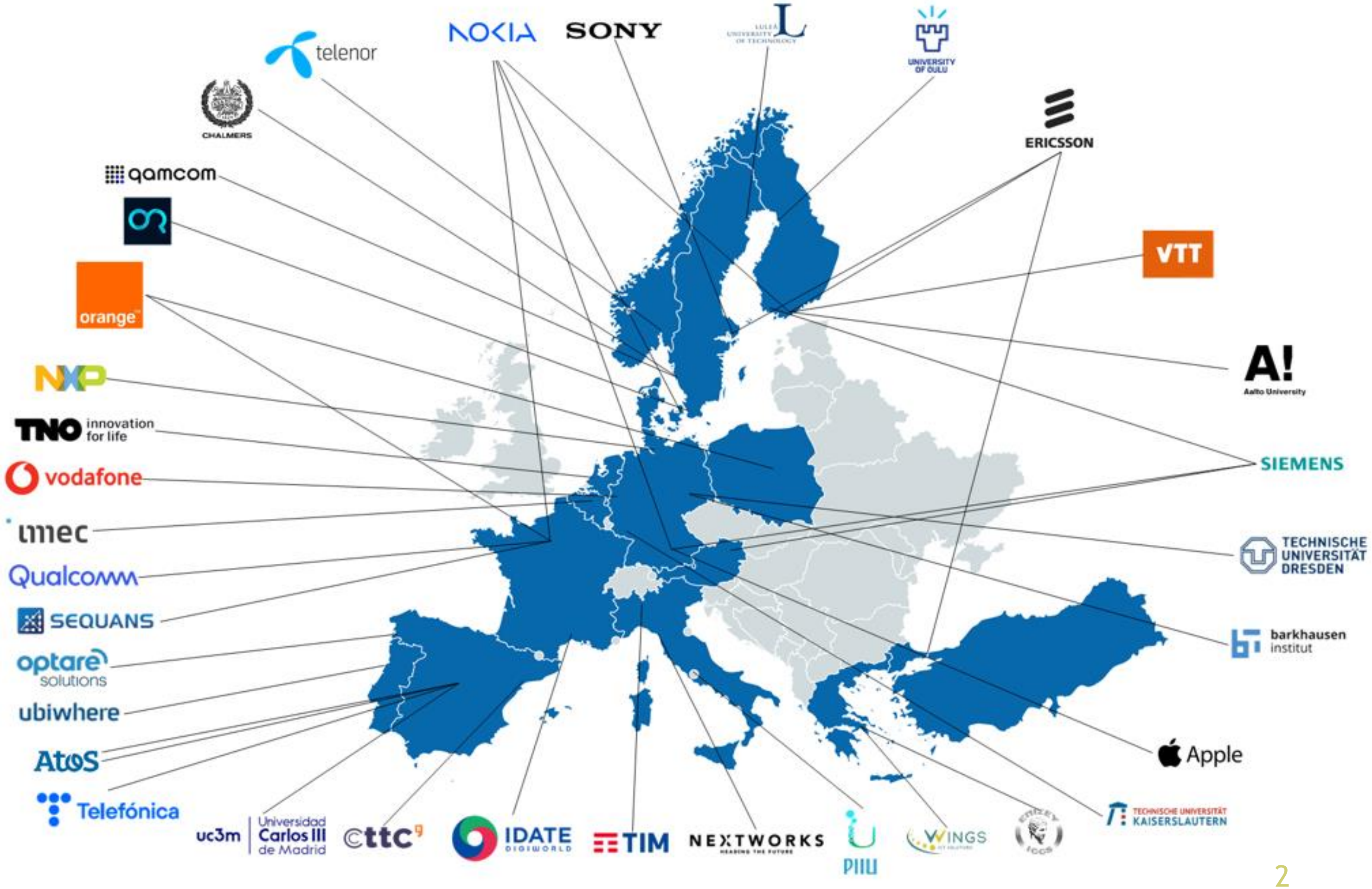
Stefan Wendt (Orange)

stefan.wendt@orange.com

hexa-x-ii.eu

Hexa-X-II overview

- Hexa-X-II is the European level 6G Flagship
- Focus is continued development of technology and define the 6G platform and system
- Funded through Horizon Europe SNS-JU
- 44 partners
    - Cover the entire value-stack from hardware to system to platform to applications to service providers and a strong academic presence
- Nokia is overall leader
- Ericsson is technical manager



Hexa-X-II European 6G Flagship
Consortium covering the entire value stack

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

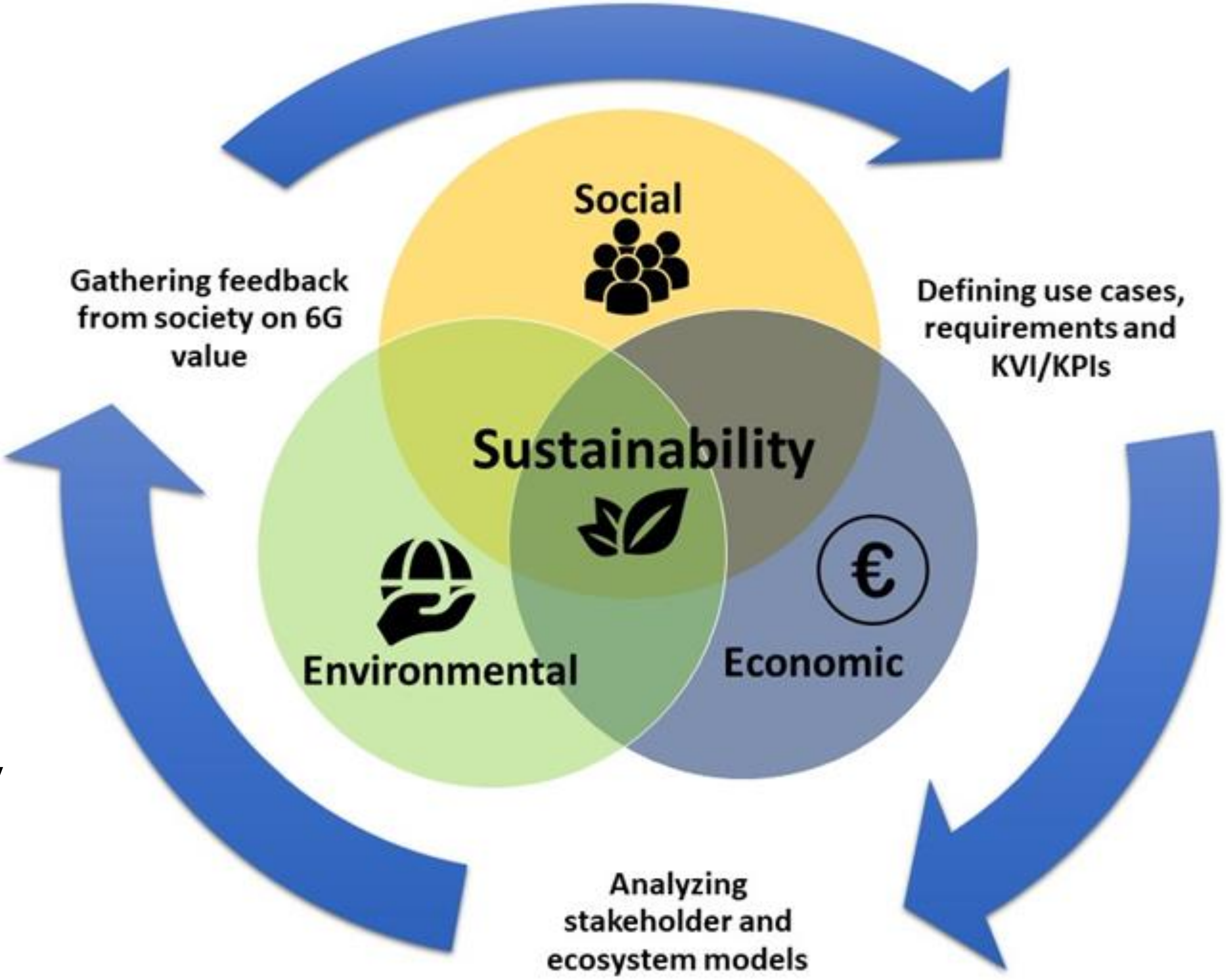
- Obtain **feedback on 6G value** addressing their needs and concerns

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

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

Use Case Families

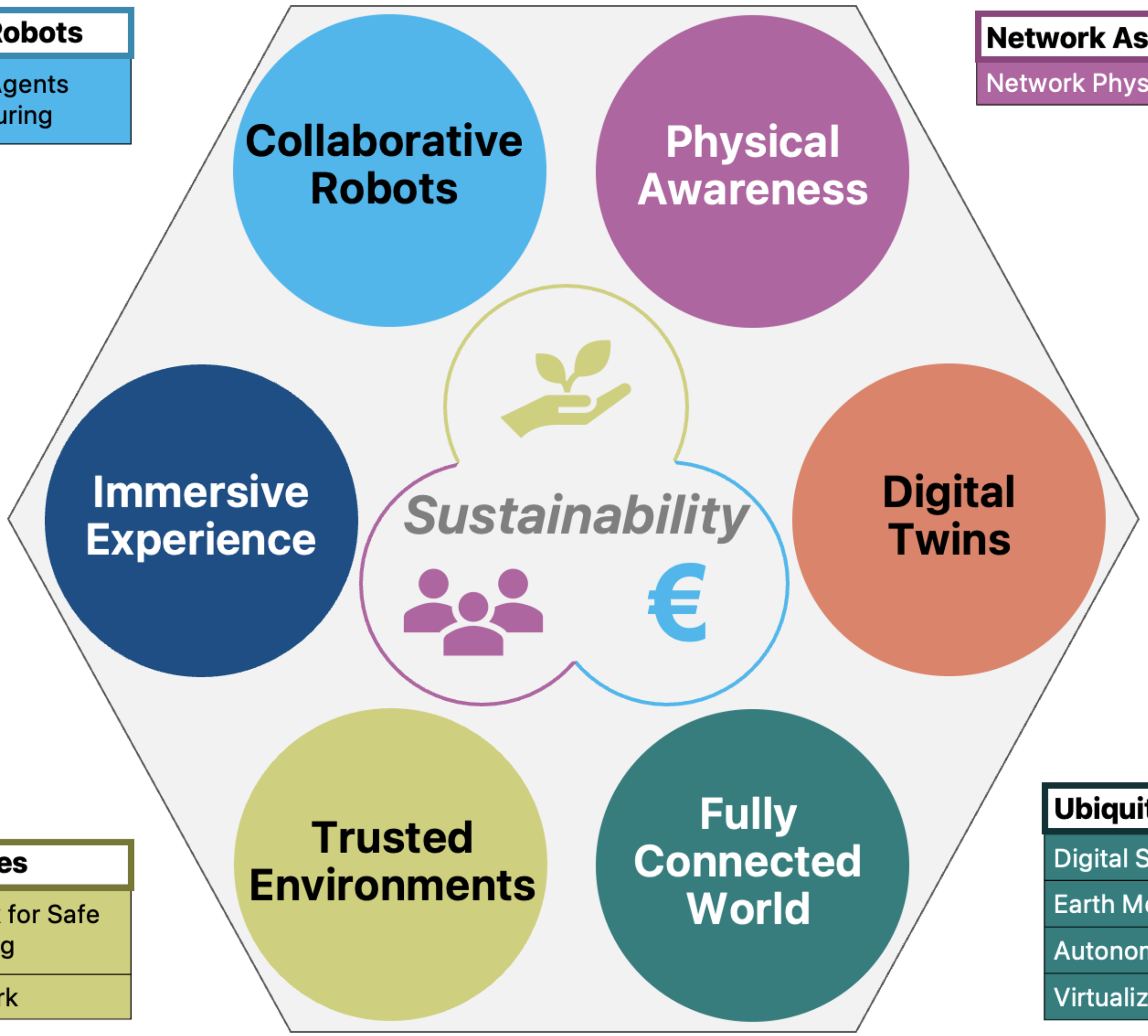
Representative Use Case

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



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

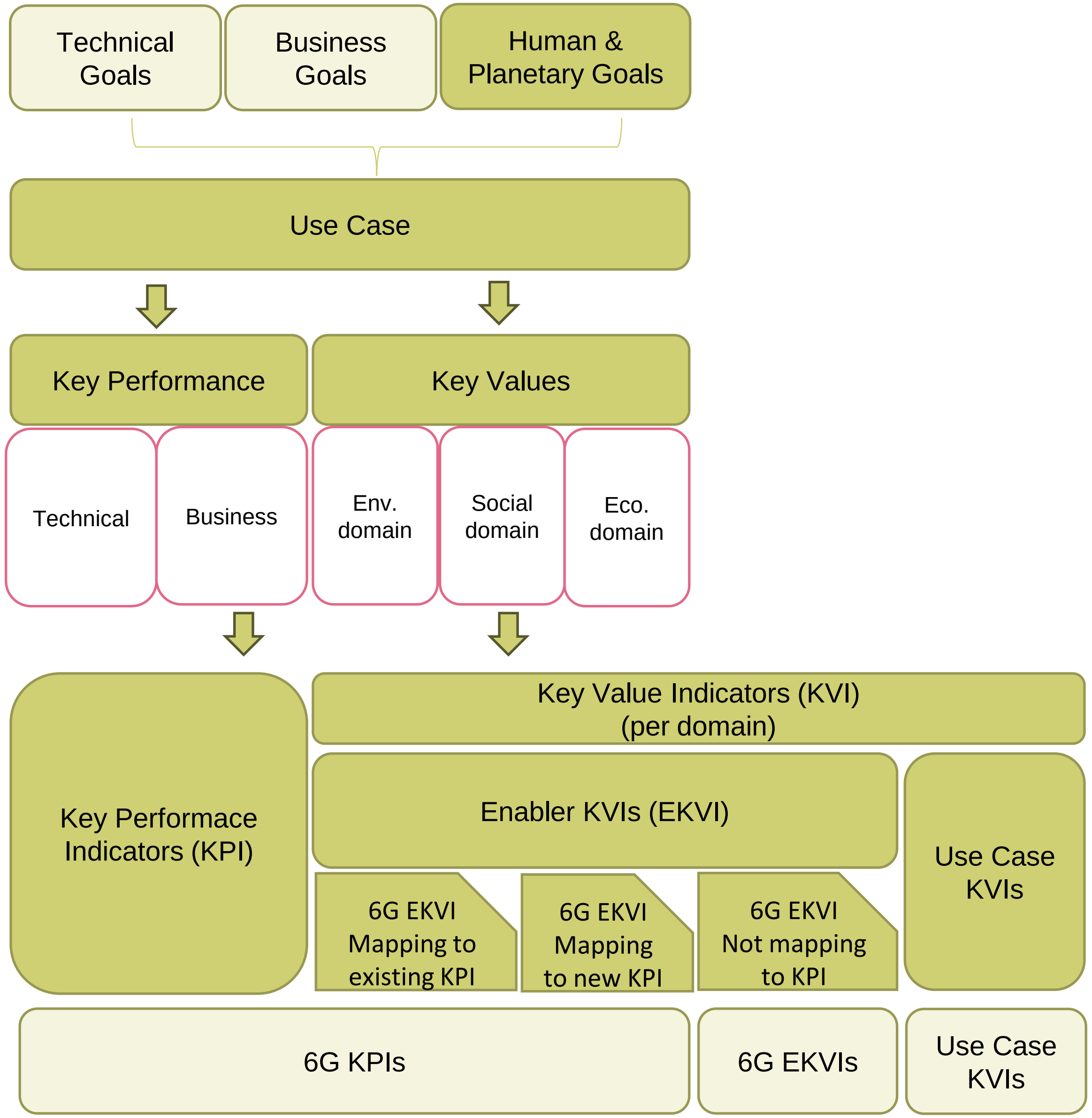
The Methodology

Analysis Methodology

Use Case

1. Use Case Analysis
2. Business Model & Stakeholder Analysis
3. Sustainability Analysis

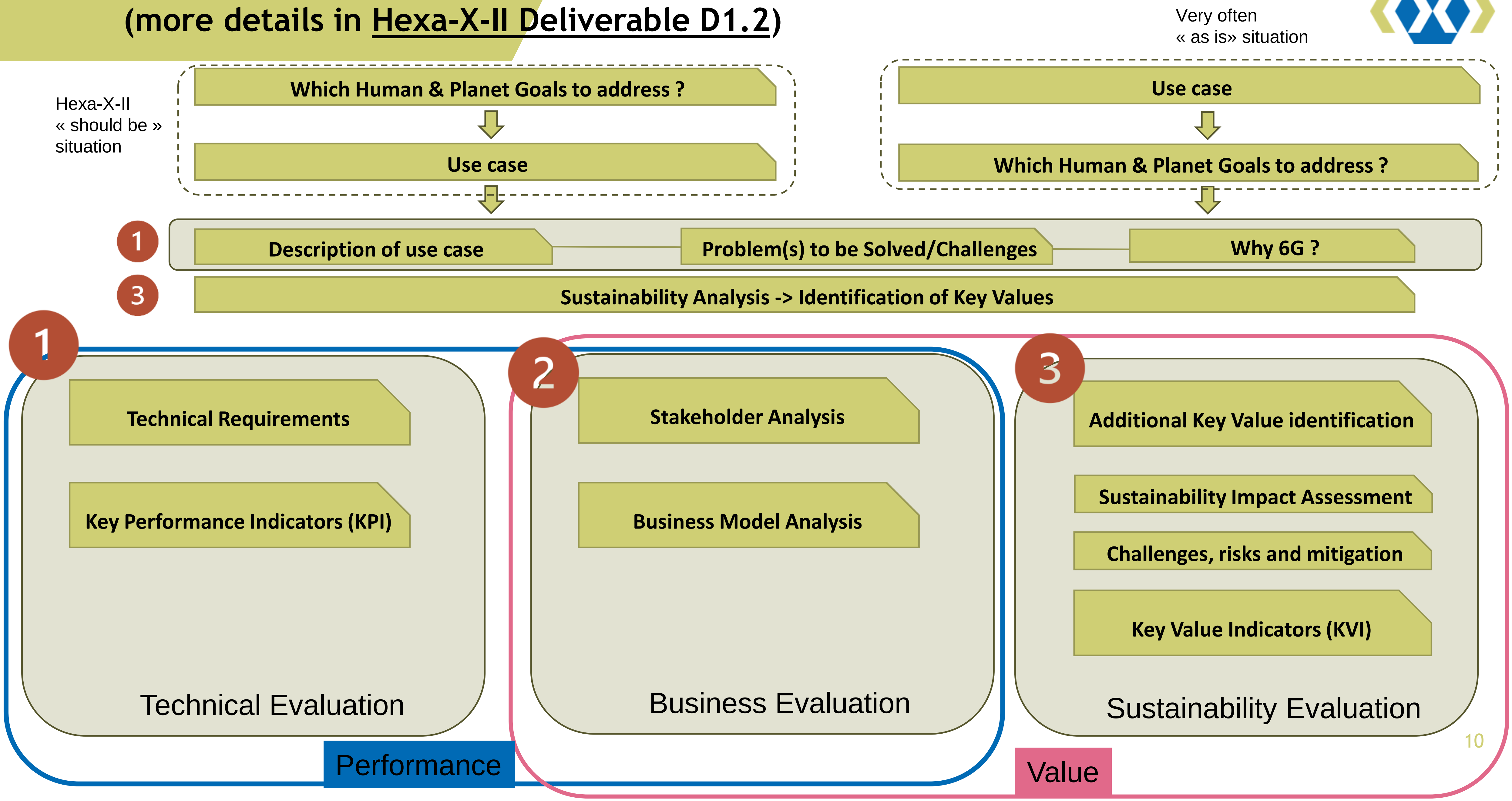
Overall Principle



Definitions

High-level Human and 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 KVIs 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 KVIs 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 & Sustainability Analysis Methodology - (more details in Hexa-X-II Deliverable D1.2)



Business Model & Stakeholder Analysis Methodology
(more details in Hexa-X-II Deliverable D1.3)

2

Business & Stakeholder Analysis
How do companies create, capture, and deliver value?

Ecosystem business model canvas
ecosystem-level business model for the use case including identification of stakeholder

Supply Side
Stakeholders/ key partners, Resources, Activities

Ecosystem Value Propositions
Value proposition
Value co-creations
Value capture
Value co-destruction
Partnerships

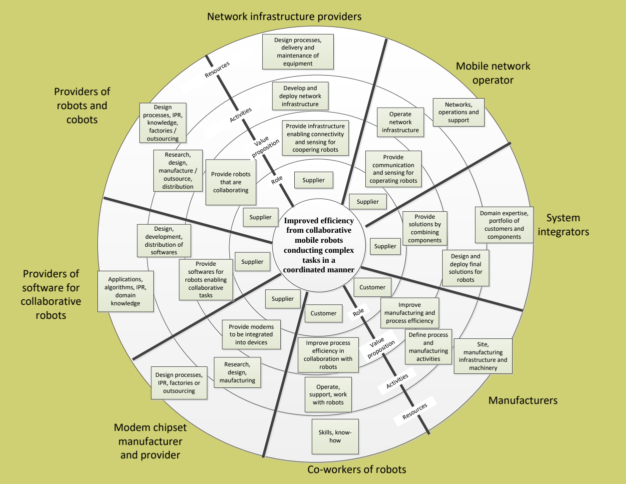
Demand side
Customer segments, Stakeholders/ key partners, Customer relationships, Channels,

Outcomes
Benefits
Revenues (revenue streams)
Pricing
Costs

Stakeholder Analaysis
analysis of key stakeholders

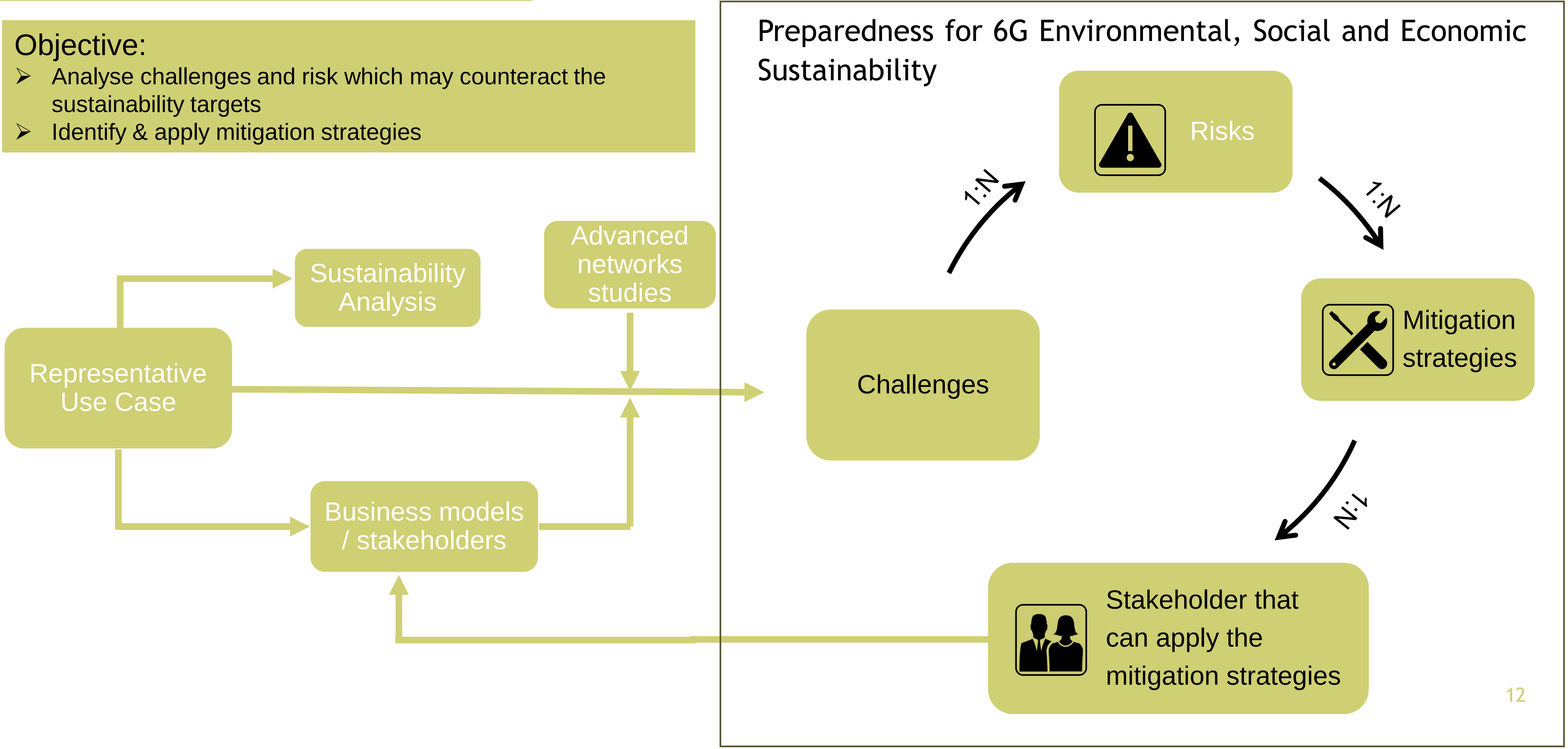
Stakeholders
Description
Role
Value Proposition
Activities
Ressources

Ecosystem pie
ecosystem-level business model visualization



3 Preparedness for 6G Sustainability - Methodology
(more details in Hexa-X-II Deliverable D1.3)

Objective:
- Analyse challenges and risk which may counteract the sustainability targets
- Identify & apply mitigation strategies



Indicative Example - Cooperating Mobile Robots

Cooperating Mobile Robots - Use Case Analysis

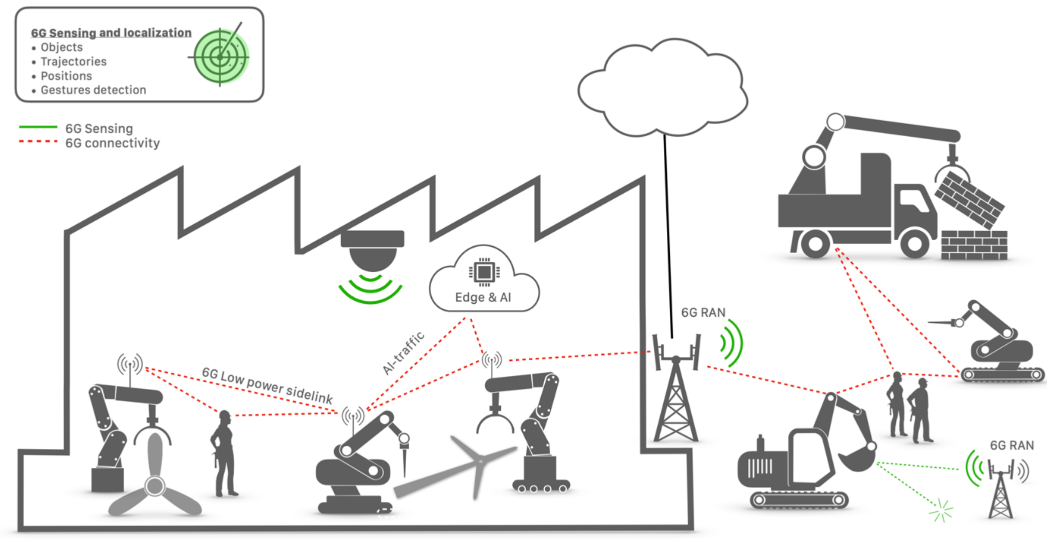
Collaborative Robots

Description

- Autonomous robots, possessing mobility, environmental sensing, and task-execution capabilities
- Robots engage in communication with each other, other machines, and nearby humans, collaborating to achieve common objectives

Applications

- Autonomous, collaborative, interactive, cooperative mobile robots
- Industrial manufacturing
- Smart living
- Construction sites



Sustainability Analysis / Key Values

	Handprints (benefits)	Footprints (costs)
Env.	• 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	• 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
Eco.	• 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

Problem(s) to be Solved/Challenges

- Understanding 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

Technical Requirements

- **Local ad hoc connectivity** – formation of task specific, localized, temporary subnetworks embedded in campus network
- **Reliable and low latency communications** – Service-level reliability and E2E latency
- **Mobility** – Frequent handovers as machines join and leave. Subnetworks nomandic behavior and roaming may occur
- **Sensing, positioning, and AI/ML** – within networks and devices (JCAS) introduction of AI/ML traffic types and AI/ML execution in edge nodes for enhanced coordination and accuracy

Cooperating Mobile Robots: Ecosystem Business Model Canvas

2

Supply Side

Stakeholders

Suppliers of robots/cobots, mobile network operators, system integrators

Resources

Networks, robots, IoT devices, data, sensing and monitoring capabilities, domain specific competences

Activities

Coordination and cooperation between stakeholders and robots, integration, circular business

Ecosystem Value Propositions

Value proposition: Improved efficiency, quality, security, flexibility and reliability from collaborative mobile robots conducting complex tasks.

Value co-creations: A total solution for robots, machines and humans to conduct tasks using network.

Value capture: Higher efficiency and economies of scale through collaborative automation.

Value co-destruction: Lack of collaboration due to interoperability challenges

Partnerships: system partnerships

Demand Side

Customer segments

Manufacturing and constructions sites, and other campuses

Stakeholders/key partners

Manufacturers, co-workers of cobots

Customer relationships

Dedicated sale and support

Channels

Digital channels, key account managers

Outcomes

Benefits

Higher resource efficiency and productivity, improved reuse of resources, cost savings

Revenues

Solution as a service, building owner investing and renting facility

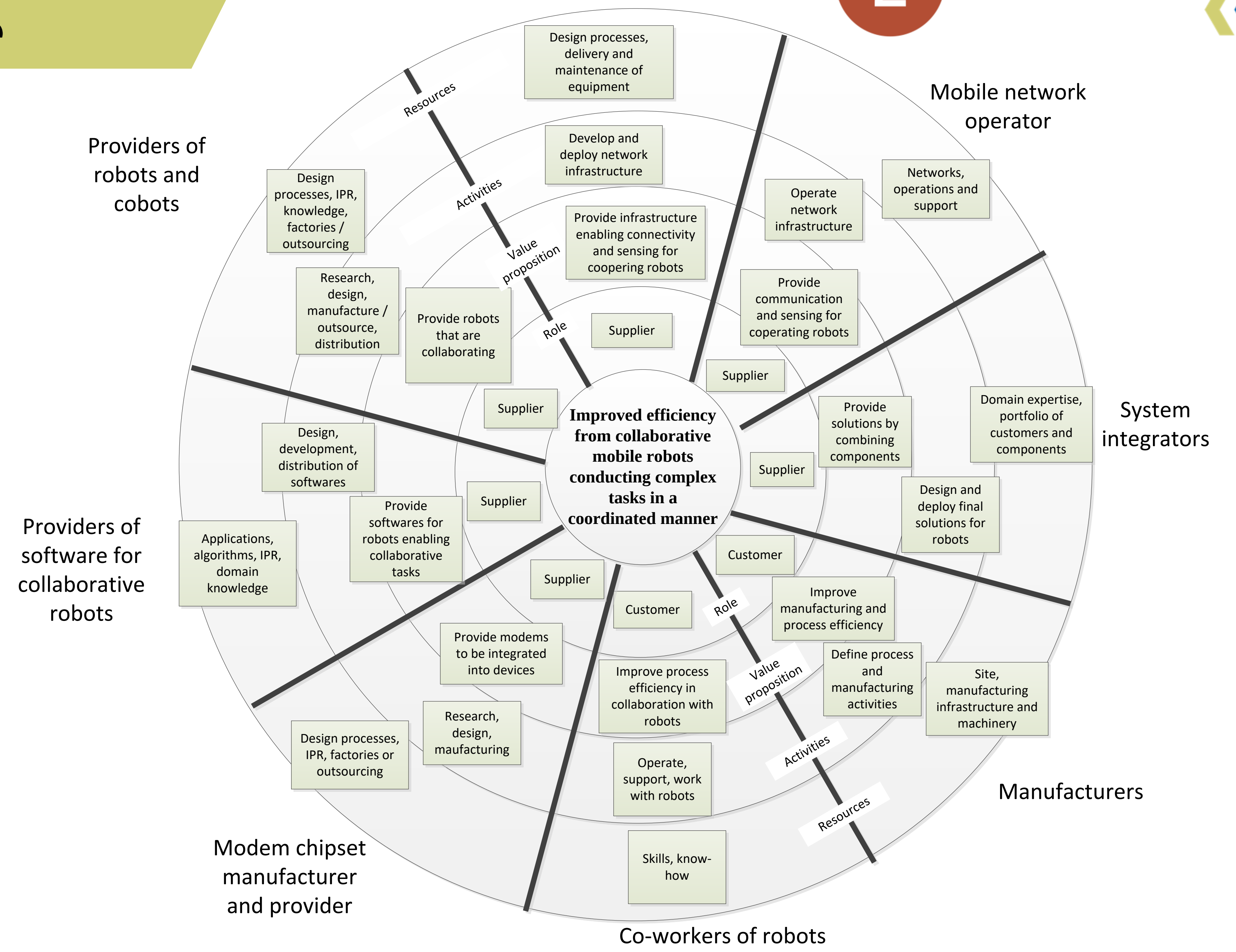
Pricing

As a service pricing models, based on improved efficiency or other values

Costs

Economic and environmental costs from manufacturing of robots/cobots, system investment costs

Cooperating Mobile Robots : Ecosystem pie



Collaborative Robots Use Case Family

Cooperating Mobile Robots: Preparedness for 6G Environmental, Social and Economic Sustainability

Parts of 3

Collaborative Robots Use Case Family

Challenges

- increased production flexibility → increased material usage and resource allocation in (robot) production, increased energy consumption in operation and e-waste formation at the end-of-life.

- Support workers performing tasks beyond their capabilities that risk their lives (e.g., carrying large weights, working in dangerous environments) vs. job losses
- Balance new processes with existing processes

- Scaling of the collaborative mobile robots' solutions to make the use case economically feasible

Risks

- Too many robots
- Jobs eliminated
- Lack of standardization

Mitigation Strategies

- Domain tailored solutions
- Smooth transition
- Reinforce standardization

Mitigating stakeholders

- Developers and operators
- Policy makers
- Operators, SDOs, alliances

Indicative example of Risks / Mitigation / Mitigation stakeholders for each sustainability axis (environmental, social, economic)

Cooperating Mobile Robots - Sustainability Analysis

Parts of 3

Collaborative Robots

Main categories for further impact analysis and assessment

Environmental	Social	Economic
Resource efficiency	Accessibility	Productivity & efficiency
Energy consumption	Work environments	New business opportunities
E-waste	Support & Distribution	Monopolization risks
Manufacturing, extraction, transportation	Privacy & Security	Investments

Conclusion(s)

Conclusion(s)

- **Sustainability** is addressed in **Environmental, Social and Economic domain**.
  - Please note that e.g. Digital Inclusion or Trustworthiness fall under Social Sustainabiliy domain
- **Use cases** have to be addressed in **Performance and Value domain**
- **High-level Human and Planetary Goals** are overall goals; e.g. the UN Specific Development Goals (SDG).
- **Key Values** represent the impact of the use case & its technology (in our case 6G) on the high-level human and planetary goals and have to be identified in the three sustainability domains
- **Key Value Indicator** is a qualitative or quantitative indicator for assessing a Key Value

There are numerous potential Key Values and Key Value Indicators, making it very difficult or impossible to cover all possibilities. Additionally, specific target values or other relative metrics need to be defined. There is thus a **need for the development of a common methodology and standardization of specific Key Values and Indicators.**

HEXA-X-II

HEXA-X-II.EU //

Co-funded by
the European Union

6GSNS

Hexa-X-II project has received funding from the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union’s Horizon Europe research and innovation programme under Grant Agreement No 101095759.

Terminology

- Preparedness for 6G Environmental, Social and Economic Sustainability
  - **Challenge** refers to difficulties or resistance that may prevent the Use case (UC) sustainability handprints and minimization of the sustainability footprints and therefore jeopardizes the potential 6G benefits for environmental, social or economic sustainability.
  - **Risks** refer to both the likelihood of not realizing the Use Case (UC) sustainability handprints and of sustainability footprints becoming larger than expected. Risks also include the likelihood of the UC resulting in not yet identified footprints. In order to identify the risks, one needs to analyse further the challenges, and describe what could go wrong so that the UC does not meet the sustainability handprints, or the sustainability footprints grow larger.
  - A **mitigation strategy** is a plan to reduce or eliminate the impact of a potential risk. The plan should take into account what technical decisions / technologies that can be applied on the 6G blueprint to help avoiding the risk not to meet environmental, social and economic sustainability targets, i.e., reduce the probability that the undesired outcome happens, or managing it in terms of reducing the undesirability of the outcome but also recommendation to stakeholders outside of the ICT sector, e.g., policy makers.

Collaborative Robots

Cooperating Mobile Robots: Requirements and KPIs

Requirements

- **Local ad hoc connectivity:** A collaborative task is characterized by its localized nature. Direct communication between connected devices allows this to be exploited, leading to the formation of subnetworks. These subnetworks, envisioned to be task-specific, temporary, and localized, are embedded within broader campus networks. This structure aids in meeting stringent latency and reliability targets within each subnetwork.

- **Extremely reliable and low latency communications:** Interruptions in industrial manufacturing operations typically entail huge financial and material loss. Safety-critical applications are intended to protect human lives. As such, applications in this domain have among the strictest service-level reliability and E2E latency requirements. The service area may be highly localized to subnetworks and increased autonomy in machines may accommodate lower reliability and higher latency.

- **Mobility:** The localized and ad hoc nature of subnetworks in a 6G environment may induce frequent handovers as machines join and leave. These subnetworks, while logically embedded in a campus network, may exhibit nomadic behavior within it, and the roaming of subnetworks between different campus networks may also occur.

- **Sensing, positioning, and AI/ML:** Integrated sensing capabilities within the 6G network and devices (JCAS/ISAC) can potentially enhance a robot's perception of its environment. The introduction of AI/ML traffic types and AI/ML execution in edge nodes can further enhance robot coordination. For maximum accuracy, it is likely that data from device-based sensors will be utilized in fusion with information from the network.

KPIs*

	KPI	Target Range	Justification
Communication	User-experience data rate [Mb/s]	< 10	Data rate between robot and campus network. Can be significantly higher locally in a subnetwork where raw sensor data and/or AI/ML traffic is exchanged.
	Connection density [devices/m^2]	< 0.1	Mobile robots occupy an area of 1 m2, and it is assumed that they occupy at most 10% of the overall area to ensure fluent mobility. The world's largest industrial manufacturing campuses accommodate thousands of robots.
	Mobility [km/h]	< 20	Slow vehicular
	End-to-end latency [ms]	< 0.8	Industrial machines may exchange coordination messages up to 200 times per second and can be triplicated for redundancy. This results in a transfer interval of ca. 1.66 ms. E2E latency limit is set to at most half that interval to ensure enough margin for ARQ. [22.104]
	Service-level reliability [%]	99.999 – 99.99999	Application-side safety net mechanism like "survival time" and "grace period" are employed to compensate occasional packet losses and delays at link level. Selected applications may have an even more strict reliability requirement up to 99.999999% [22.104].
	Coverage [%]	—	Localized nature of a joint task makes local ad hoc connectivity favourable.
Positioning & New Capabilities	Positioning accuracy [m]	< 0.1 (fine) < 1 (coarse)	Tasks such as environment mapping, robot navigation, and inventory management require fine positioning. Tasks like robot localization need coarse positioning.
	Sensing-related capabilities [Y/N]	Y	Robots and cobots depend on capturing the environmental context. Network-integrated sensing may complement or replace dedicated on-board sensors. Efficient transport of data/information from connected external sensors likely needed.
	AI/ML-related capabilities [Y/N]	Y	Robots and cobots depend on advanced machine learning. Execution may be embedded in the device and/or offloaded at a local edge and/or provided by the network as an over-the-top service.

*As the IMT-2030 capability-related KPI values 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 are only meaningful 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 within as well as beyond this project