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6G4SOCIETY

D4.4 EXPLOITATION REPORT v2

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Abstract	This deliverable consists the final exploitation strategy of the 6G4Society project, consolidating Key Exploitable Results (KERs), individual and joint exploitation pathways and sustainability prospects. It reflects the consortium's efforts to ensure long-term impact beyond the project duration.
Keywords	6G, societal acceptance, sustainability, societal values, Key Value Indicators (KVIs), Key Sustainability Indicators (KSIs), Social Acceptance of Technology (SAT), Technology Acceptance Model (TAM), social impact, standardisation, policy recommendations, exploitation strategy, Key Exploitable Results

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DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

DATA: Data sets, microdata, etc.

DMP: Data management plan

ETHICS: Deliverables related to ethics issues.

SECURITY: Deliverables related to security issues

OTHER: Software, technical diagram, algorithms, models, etc.

EXECUTIVE SUMMARY

Deliverable D4.4 outlines the final exploitation and sustainability strategy of the 6G4Society project, building on earlier work conducted during the first half of the project and reflecting updated contributions from KER owners. The report begins by presenting an overview of the strategic approach, including the categorisation and refinement process that led to the final list of Key Exploitable Results (KERs), grouped under three main areas: (i) Frameworks, Tools & Services, (ii) Knowledge, Dissemination & Engagement and (iii) Joint Exploitation Initiatives.

For each KER, the report documents the relevant owner, potential target audiences, exploitation objectives and planned follow-up actions. In addition, two suggested joint exploitation concepts: the Competence Centre and the Pool of Experts (HUB) are presented, both conceived during the second phase of the project as forward-looking mechanisms to sustain and maximise project outcomes. Although not included in the original work plan, these initiatives represent strategic opportunities to preserve and activate the project's legacy.

Finally, the report addresses feasibility aspects, potential funding models and recommendations for future uptake, while aligning with the SNS JU's broader goals of societal impact, inclusivity, and long-term sustainability in 6G research and innovation.

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ABBREVIATIONS

3GPP	3rd Generation Partnership Project
5G	Fifth Generation
5G-PPP	5G Infrastructure Public Private Partnership
6G	Sixth Generation
AI	Artificial Intelligence
ALTAI	Assessment List for Trustworthy AI
API	Application Programming Interface
CEN	European Committee for Standardization
CSA	Coordination and Support Action
CQ	Competence Question
CRA	Cyber Resilience Act
CWA	CEN Workshop Agreement
DOI	Diffusion of Innovations
ETSI	European Telecommunications Standards Institute
EU	European Union
GDPR	General Data Protection Regulation
IMT	International Mobile Telecommunications
IoT	Internet of Things
IP	Internet Protocol
IPR	Intellectual Property Rights
ISAC	Integrated Sensing and Communication
IT	Information Technology
ITU	International Telecommunication Union
KERs	Key Exploitable Results
KPI	Key Performance Indicator
KSIs	Key Sustainability Indicators

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KVs	Key Values
KVIs	Key Value Indicators
NeOn	Networked Ontologies
NGMN	Next Generation Mobile Networks
NOR	Non-Ontological Resource
NTN	Non-Terrestrial Networks
ORE	Open Research Europe
ORSD	Ontology Requirements Specification Document
OWL	Web Ontology Language
PPDR	Public Protection and Disaster Relief
RF	Radio Frequency
RRI	Responsible Research and Innovation
SAT	Social Acceptance of Technology
SbD	Sustainability-by-Design
SDG	Sustainable Development Goal
SIA	Social Impact Assessment
SNS JU	Smart Networks and Services Joint Undertaking
SNVC WG	Societal Needs and Value Creation Working Group
TAM	Technology Acceptance Model
TCP	Transmission Control Protocol
THz	Terahertz
TMV WG	*Test Measurement and Validation Working Group*
TRL	Technology Readiness Level
UAV	Unmanned Aerial Vehicle
UN	United Nations
UTAUT	Unified Theory of Acceptance and Use of Technology
VSD	Value Sensitive Design
WP	Work Package

1 INTRODUCTION

Deliverable D4.4 “Exploitation Report v2” provides the final assessment of the Key Exploitable Results (KERs) identified within the 6G4Society project. Building on the preliminary work documented in D4.3, this deliverable refines the project's exploitation strategy, incorporating updated inputs from all partners and reflecting the project's evolving innovation landscape.

The aim of this deliverable is to support long-term sustainability and uptake of project results by providing an up-to-date overview of the exploitable assets developed throughout the project, along with their individual and joint exploitation pathways. Particular attention is given to strategic legacy proposals introduced during the second half of the project, such as the 6G4Society Competence Centre and the Pool of Experts (HUB), which have been elaborated through feasibility studies included in this deliverable. These initiatives are exploratory legacy mechanisms proposed during the second project phase and do not constitute contractual obligations under the Grant Agreement.

This report aligns with the broader SNS JU objectives by outlining how the project’s results can deliver continued societal, technological and policy impact beyond its lifetime. By consolidating the knowledge generated and defining viable exploitation pathways, it supports future initiatives aiming to integrate ethical, sustainable and inclusive values into the development and deployment of next-generation networks.

2 EXPLOITATION AND SUSTAINABILITY

This chapter provides an overview of the project's approach to exploitation and sustainability, with a particular focus on how the project's Key Exploitable Results (KERs) have been identified, refined and prepared for long-term uptake. It also summarises the strategic vision behind the exploitation framework and highlights the main instruments supporting sustainability beyond the project's lifetime.

2.1 Overview of Exploitation Strategy

The exploitation strategy of 6G4Society was developed with a strong focus on long-term impact generation, sustainability and alignment with the strategic goals of the Smart Networks and Services Joint Undertaking (SNS JU). Rather than aiming for direct commercialisation of technical outputs, the project's exploitation activities were oriented toward knowledge transfer, policy influence and capacity-building around the non-technical dimensions of 6G.

Throughout the project, efforts were made to identify and nurture KERs that could have real-world relevance for stakeholders, including research institutions, public authorities, industry actors and the broader SNS ecosystem. These KERs built on the project's contributions to concepts such as Key Values (KVs), Key Value Indicators (KVIs) and the social acceptance of 6G technologies.

To ensure clarity and facilitate targeted exploitation pathways, KERs were grouped into three main categories:

1. **Frameworks, Tools & Services**: conceptual and methodological outputs ready for uptake and reuse
2. **Knowledge, Dissemination & Engagement**: material and channels for spreading awareness and engaging with stakeholders
3. **Joint Exploitation**: possible legacy structures or collaborative mechanisms beyond the project's lifetime.

2.2 Refinement of KERs

The identification and refinement of the project's KERs was an iterative, collaborative process that evolved throughout the 6G4Society implementation period. It involved contributions from all partners, led and coordinated by eBOS under Task 4.2 and aligned with the evolving priorities of the SNS JU and the broader European 6G ecosystem.

Initially, a wide range of potential results, ranging from conceptual frameworks to outreach activities were proposed by individual partners. To structure and evaluate these, a KER mapping and prioritisation template was developed and shared across the consortium. This Excel-based tracker captured key information for each proposed KER, including:

- Lead organisation and contributors
- Title and type of KER (e.g. tool, framework, brief, platform, service)
- Description and Technology Readiness Level (TRL)
- Target stakeholders and potential users
- Exploitation potential (e.g. commercial, open-source, policy)
- Maturity and future ownership plans
- Alignment with SNS JU Key Performance Indicators (KPIs) and impact areas

Following multiple review rounds, several results were merged, reworded or consolidated into more cohesive outcomes. For example, policy and operational briefs were grouped under a single KER, while joint initiatives such as the Competence Centre and Pool of Experts were recognised as potential legacy mechanisms that cut across individual WP contributions.

The result is a focused and feasible set of KERs that represent both the conceptual innovation and practical utility of 6G4Society, while laying the foundation for sustained engagement and uptake within the SNS ecosystem.

2.3 List of Key Exploitable Results

Table 1 presents the finalised list of KERs developed in 6G4Society, which were identified and refined in collaboration with all KER owners and represent a diverse portfolio of assets that can support future work in the SNS JU and beyond.

TABLE 1: LIST OF KERS

KER	Lead Partner(s)
Framework, Tools and Services	
SAT Framework Application	CSL
KVI Ontology	NOVA
KSI Framework	PSC
Four Policy Briefs and Four Operational Briefs	CSL
Knowledge, Dissemination & Engagement	
Generated Knowledge	D4P
Joint Exploitation	
Competence centre	All partners
Pool of Experts (HUB)	All partners

The exploitation strategy for each KER is presented in detail in Chapter 3.

3 EXPLOITATION STRATEGIES PER KER

3.1 Frameworks, Tools & Services

3.1.1 SAT Framework Application

3.1.1.1 Description and Innovation

In today's landscape, the social acceptance of new technologies has become a critical success factor for innovative projects. The SAT (Social Acceptance of Technology) framework developed by CyberEthics Lab. and enhanced by CyberSocial Lab. was conceived precisely to assess a technology's acceptability and acceptance through a multi-level socio-technical analysis. SAT aims to bridge the gap between technological innovation, ethical requirements, and societal acceptance by examining how technologies interact with society across systemic, societal, and individual levels. The framework helps identify potential value tensions, governance challenges, and trust issues from the earliest stages of development, enabling proactive technology design that aligns with societal values rather than merely reacting to public resistance. For instance, as outlined in project deliverable D1.1, the rollout of 5G networks revealed how lacking social acceptance can lead to boycotts or even vandalism. Such episodes highlight the need for structured tools like SAT to understand and foster stakeholder trust and acceptance of emerging technologies through comprehensive analysis of controversies, institutional dynamics, and the broader socio-technical context.

SAT bridges that gap by providing a structured, stepwise evaluation that combines empirical and normative dimensions. The framework operates across three analytical levels, individual, societal, and systemic, while bridging the acceptance-acceptability spectrum. In other words, SAT tries to close the loop by examining how individual user experiences, community and institutional dynamics, and broader ethical considerations interact and shape technology-society relationships. This multi-level approach captures what no single competing framework achieves: a comprehensive view of how infrastructure innovations require collective negotiation, not merely individual adoption.

SAT offers an integrated methodology that addresses a critical gap in technology assessment: where TAM[1] focuses primarily on individual adoption likelihood, and SIA[2] identifies social issues without providing design guidance, SAT connects assessment to actionable technology design. The framework examines not only individual user perceptions but also how technology intersects with community values, institutional arrangements, and societal structures. By identifying where acceptance barriers emerge, whether from user experience issues, governance challenges, value conflicts, or trust deficits, SAT enables innovation teams to address these concerns proactively during development rather than reactively after deployment.

Therefore, one of **SAT's key strengths is its proactive nature**: it assesses not only whether a technology achieves social acceptance, but also how to design for acceptance from the outset. Traditional user acceptance methods evaluate whether users find a technology useful, but they do not address how to design it in line with societal values, institutional requirements,

[1] F. D. Davis, "Technology acceptance model: TAM.," in *Information Seeking Behavior and Technology Adoption*, 1989, pp. 205-219.

[2] H. A. Becker & F. Vanclay "The International Handbook of Social Impact Assessment: Conceptual and Methodological Advances" (2003)

or ethical considerations. SAT stands out as a holistic approach that integrates multiple perspectives into a coherent methodology. Through its four dimensions (User Experience, Social Disruptiveness, Value Impact, Trust), the framework pinpoints exactly where acceptance barriers exist: whether in poor usability, institutional disruption, misalignment with moral values (ethical concerns), or erosion of trust. This diagnostic capability enables targeted interventions at each dimension rather than generic responses to resistance.

Moreover, **SAT's unique value** lies in its dual focus: identifying acceptance factors and guiding enhancement strategies. The framework tracks societal feedback while helping define ethics-driven design approaches that reduce barriers such as distrust and misinformation and foster wider, faster deployment. Many existing tools are either measurement-oriented (TAM quantifies adoption intention quantitatively; SLO gauging community sentiment qualitatively) or principle-oriented (RRI sets out principles without operationalisation) whereas SAT, along with KVIs, does both. This integration positions SAT as both an assessment instrument and a design compass for responsible innovation.

3.1.1.2 Comparative analysis

A list of key frameworks and models related to technology acceptance and social innovation have already been developed. However, they often are the result of research conducted in the past years and don't have a direct commercial use. The next table shows the most prominent and the comparative advantages of SAT. It serves as an integrated framework designed to identify, assess, and enhance social acceptance across technological, organisational, and societal contexts. While many of the models below focus on specific aspects of user behaviour, diffusion, or stakeholder engagement, SAT provides a holistic, multi-level approach that incorporates societal, community, and market perspectives within a consistent evaluative structure. Table 2 provides a comparative overview of each framework, its commercial application, and how the SAT improves upon or complements it.

TABLE 2: SAT FRAMEWORK COMPARATIVE ADVANTAGES

Framework / Model	Commercial Status	Explanation	Advantage of SAT
Technology Acceptance Model[3] (TAM) & UTAUT	Applied commercially (no proprietary tool)	Freely available theoretical frameworks used in consulting, UX research, and internal acceptance surveys; no license or dedicated software.	SAT offers a broader societal and multi-stakeholder perspective, extending beyond individual behavioural intention to include community and institutional acceptance.

[3] F. D. Davis, "Technology acceptance model: TAM.," in *Information Seeking Behavior and Technology Adoption*, 1989, pp. 205-219.

Diffusion of Innovations (DOI)[4]	Applied commercially (no proprietary tool)	Open academic model often used in marketing, product diffusion planning, and change management; no dedicated software or license.	SAT provides a more systematic, evidence-based evaluation of acceptance, while Rogers' model focuses more on descriptive diffusion patterns over time.
Triangle of Social Acceptance[5]	Applied commercially (no proprietary tool)	Academic concept used by energy and infrastructure consultants for stakeholder and community acceptance analyses.	SAT operationalises multi-level acceptance (macro, meso, micro) with clearer assessment tools, making it more practical and transferable.
Social Impact Assessment (SIA)[6]	Commercial consulting service	Delivered by specialised consulting firms as part of environmental and social assessment processes. Open methodology, often legally required.	SAT complements SIA by focusing specifically on acceptance and societal trust dimensions rather than only impacts.
Value Sensitive Design (VSD)[7]	Applied commercially (no proprietary tool)	Open academic design methodology. Used in ethical innovation and UX consulting but not tied to specific commercial software.	SAT can be applied post-design to evaluate real-world acceptance outcomes, while VSD focuses mainly on design-stage ethical integration.

[4] E. M. Rogers, Diffusion of innovations, New York: Free Press, 2003.
[5] R. Wüstenhagen, M. Wolsink and M. J. Bürer, "Social acceptance of renewable energy innovation: An introduction to the concept," *Energy Policy,* vol. 35, no. 5, p. 2683–2691, 2007.
[6] H. A. Becker & F. Vanclay "The International Handbook of Social Impact Assessment: Conceptual and Methodological Advances" (2003)
[7] Friedman, Batya & Kahn, Peter & Borning, Alan & Zhang, Ping & Galletta, Dennis. (2006). "Value Sensitive Design and Information Systems." 10.1007/978-94-007-7844-3_4.

ALTAI – Assessment List for Trustworthy AI[8]	Free tool with commercial support services	EU-developed free checklist for AI ethics. Consulting and law firms offer paid assistance for assessment and compliance implementation.	SAT extends ALTAI's principles beyond AI ethics to a broader range of technologies and social contexts, providing a holistic acceptance assessment framework.
Responsible Research and Innovation (RRI)[9]	Training service	EU-promoted open framework. Consultants and ethics experts provide RRI implementation, training, and governance support.	SAT offers a more focused operational tool for measuring acceptance, whereas RRI covers broader governance and ethical processes.

3.1.1.3 Target Stakeholders

- Research consortia & EU projects: Research partners in EU projects requiring societal acceptance assessment as part of their innovation development process.
- High-tech industries: Firms developing innovative products (AI software, IoT, devices, autonomous systems) with a vested interest in ensuring social and market acceptance while avoiding public backlash. These early adopters can serve as reference cases demonstrating SAT's practical value.
- Telecom & infrastructure operators: Organizations deploying 5G/6G networks, utilities implementing smart meters, or energy companies developing wind farms. These actors face public and municipal scrutiny and can benefit from SAT's ability to address local concerns and navigate controversies.
- Universities e think-tanks: Academic institutions interested in collaborative validation and refinement of the SAT framework through joint studies and publications, lending academic credibility to the methodology while contributing cutting-edge insights on acceptance dynamics.
- Complementary consultancies: Firms specializing in environmental assessment, economic impact analysis, and regulatory compliance to provide comprehensive technology assessment services.
- Government bodies & Smart City programmes: Municipalities or regional governments implementing smart city technologies (surveillance systems, traffic management AI, data platforms) that require citizen acceptance. They can use SAT to guide community engagement and inform technology design decisions.

[8] European Commission – High-Level Expert Group on Artificial Intelligence (AI HLEG), "Assessment List for Trustworthy Artificial Intelligence (ALTAI)", 17 July 2020

[9] Schomberg, Rene. (2011). "Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Field." SSRN Electronic Journal. 10.2139/ssrn.2436399.

- Institutional networks: Networks such as living labs, standardisation committees, smart city associations that can help influence policy, provide methodological endorsements, and facilitate access to potential adopters.

3.1.1.4 Use Cases and Scenarios

The SAT framework has been and continues to be applied in several EU-funded projects across multiple domains. It was successfully employed in past initiatives such as 5G-SOLUTIONS (next-generation communication technologies), IRIS (security in smart cities) and BRIGHT (energy systems), and it is currently being applied in ongoing projects including SUSTAIN-6G (next-generation communication technologies), COMFORTAge (health technologies) and PRESEVE (security domain).

Its modular architecture is technology-agnostic and adaptable, making it a versatile tool for any sector where understanding and enhancing technology **acceptance** and **acceptability** is essential. SAT provides a structured assessment of stakeholder perceptions, value alignment, trust dynamics, and potential societal impacts through analysis of controversies, ethical considerations, and multi-level acceptance factors. The framework can be applied across multiple sectors, including:

- Healthcare sector: Hospitals, health services, and medical technology companies deploying telemedicine platforms, AI diagnostic tools, or patient data management systems. Acceptance by clinicians, patients and the general public, particularly regarding trust in AI-based diagnostics and privacy concerns, is critical for successful implementation.
- Energy & Environment sector: Renewable energy projects (wind farms, solar installations) and large-scale infrastructure developments where community acceptance is essential. SAT's assessment of trust, value alignment, and social disruption helps identify and address barriers to local acceptance.
- AI & Autonomous Systems: Organisations developing or deploying AI technologies who must address ethical concerns, value alignment and stakeholder trust from early development stages. SAT's comprehensive approach components existing frameworks (such as ALTAI) by examining how AI systems interact with societal values and institutional arrangements, while tracking stakeholder perceptions across the technology lifecycle.

3.1.1.5 TRL and next steps for readiness

The SAT framework has evolved through several EU-funded research projects (including 5G-SOLUTIONS, IRIS, BRIGHT, COMFORTAge, and 6G4Society) with continuous refinement and adaptation to address specific technological and domain contexts. Within the 6G4Society project, the framework has been further developed and validated, achieving a maturity level suitable for application in research and pilot initiatives, particularly those related to 6G and other emerging connectivity technologies.

The framework's research readiness is well established, supported by a documented methodology, peer-reviewed publications, and demonstrated applications across multiple domains.

Therefore, while its research readiness is established, commercialisation efforts are still ongoing. The next phase of development focuses on enhancing scalability, defining standardized assessment protocols, and advancing digital tools to facilitate wider adoption by industry stakeholders and policymakers. This continued evolution builds on a robust methodological foundation grounded in both academic research and practical implementation.

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3.1.1.6 Commercial Roadmap

3.1.1.6.1 Market trends and commercial potential

In recent years, social acceptance of technology has evolved from a narrow focus on individual adoption behaviour, as captured by models like TAM and UTAUT, to a broader, systemic understanding of how technologies interact with societal values, institutions, and governance structures. This marks a significant shift toward multi-level frameworks that consider not only users, but also communities, policymakers, and markets as interlinked actors in the acceptance process.

A notable new trend is the integration of trust, legitimacy, and ethics into acceptance research. Particularly in fields such as artificial intelligence, automation, and data-driven governance, acceptance is increasingly linked to perceptions of fairness, transparency, and accountability, rather than just usefulness or usability. This reflects a paradigm shift from usability to trustability, where the success of innovation depends as much on perceived moral legitimacy as on technical performance.

Methodologically, there is growing use of mixed and data-driven approaches that combine surveys, ethnographic insights, and computational tools (e.g., machine learning and sentiment analysis) to map evolving social attitudes and predict adoption patterns. This quantitative-qualitative convergence allows for dynamic tracking of how acceptance changes over time, **recognising it as a process** rather than a one-time event. Overall, a convergence is emerging, successful technologies are not just adopted, they need to be socially validated through trust, dialogue, and transparent governance. To this extent, participatory innovation ecosystems such as Living Labs and co-creation platforms foster collaboration among citizens, researchers, industry, and government, making technology design more inclusive and contextually grounded. Such initiatives demonstrate a market preference for real-world experimentation and stakeholder engagement as essential conditions for legitimacy.

In this context, SAT plays a pivotal role, with **significant potential** for both research and industry.

From the research perspective, SAT provides a comprehensive framework enabling researchers to identify social controversies and underlying values, measure technological impacts, disruptiveness, and trust, and evaluate user acceptance through a holistic, cross-domain lens. It supports scientific studies across technologies and contexts, fostering a more integrated understanding of societal responses to innovation.

Stated that SAT is not yet a market-ready product, from the market perspective, SAT has the potential to serve as a practical instrument addressing the growing need of organisations to assess public trust, legitimacy, and social acceptance prior to large-scale deployment. This is particularly relevant in emerging sectors such as 6G, artificial intelligence, smart cities, the energy transition, and mobility systems, where societal endorsement is a key determinant of success.

3.1.1.6.2 Planned Services

SAT assessment services are structured around the framework's multi-stage methodology and can be tailored to different technology readiness levels and organizational needs:

- Preliminary contextualisation and controversy mapping: Initial assessment to determine whether the focus should be on acceptability (forward-looking, ex-ante) or acceptance (empirical, ex-post), identification of what is to be accepted and who should accept it, and mapping of relevant public controversies to identify contentious aspects and key stakeholders.

- Stakeholder identification and engagement planning: Comprehensive mapping of stakeholders using the socio-technical system perspective, incorporating power, legitimacy, urgency, and potential harm as identifying attributes. This includes passive stakeholders who may be impacted by the technology but lack direct influence over its development, ensuring inclusive representation across diverse groups.
- Multi-dimensional assessment design: Development of customized assessment approaches using SAT's four dimensions (User Experience, Social Disruptiveness, Value Impact, and Trust). Methods are selected based on technology maturity and may include desk research, expert consultation, for emerging technologies, and empirical data collection for existing systems.
- Design guidance and requirements development: Translation of assessment findings into actionable design recommendations, technology requirements, and implementation strategies that address identified barriers and align with stakeholder values. This may include co-design activities with stakeholders to ensure technologies reflect diverse needs and priorities.
- Longitudinal monitoring and adaptation: Ongoing tracking of key acceptance indicators throughout technology development and deployment, enabling iterative refinement of strategies as technology and stakeholder perceptions evolve.
- Knowledge transfer and capacity building: Workshops, training sessions, and awareness-raising activities for research teams, industry practitioners, policymakers, and public audiences to build understanding of social acceptance dynamics and responsible innovation practices.
- Strategic reporting and recommendations: Comprehensive documentation findings, assessment of acceptance risks and opportunities, and concrete recommendations for technology design, communication strategies, policy development, and stakeholder engagement. Reports are structured for different audiences including technical teams, decision-makers, and policy actors.

3.1.1.6.3 Competitor analysis

Building on the SAT framework, CyberSocial Lab. is able to offer specialised consultancy and research services that address the social dimensions of technology. Compared with other organisations, the key strength of CyberSocial Lab. lies in its multidisciplinary approach, specialised expertise and established reputation, built through extensive research and participation in European and international projects. Most significant competitors are affiliated with large consulting groups or broad-spectrum IT companies, while only a few are exclusively focused on the intersection between technology and social impact. In this context, Cybersocial Lab's multidisciplinarity encompassing both the social sciences and engineering, academic credibility and experience in innovative initiatives (such as research, pilot, and grant-funded projects), represent a distinctive competitive advantage in the market. For the market landscape, the following table provides a comparative overview:

TABLE 3: MARKET LANDSCAPE OVERVIEW

Competitor	Strengths	Weaknesses
Academic Institutions	Deep expertise, established reputations	Lack of business focus, slower to adapt

Think Tanks	Policy influence, broad networks	Lack of technical depth, often have ideological biases
Traditional Consultancy Firms	Established client relationships, broad service offerings	Lack of specialised knowledge in emerging tech ethics and social values
Tech Ethics Startups	Agile, often with cutting-edge knowledge	Lack of established reputation, limited resources
In-house Corporate Ethics Teams	Deep understanding of specific company context	Potential for bias, limited external perspective

3.1.1.7 Academic Roadmap

3.1.1.7.1 Plans for research publications

The dissemination of SAT through academic publications is currently under development as part of CyberSocial Lab.'s broader research exploitation strategy. Building on the empirical work conducted through 6G4Society and earlier projects, CyberSocial Lab. is working to identify the most appropriate venues and publication formats to maximise the framework's impact within relevant research communities.

The approach to academic dissemination recognises the interdisciplinary nature of technology acceptance research, which spans innovation studies, telecommunications research, science and technology studies, and policy scholarship. Publication opportunities across these diverse fields are under evaluation, to position SAT where it can contribute most effectively to ongoing scholarly conversations about technology-society relationships, responsible innovation, and stakeholder engagement.

Target journals are being identified based on their relevance to social acceptance research, their reach within practitioner and policy communities, and their alignment with open access principles required by EU funding programmes. Venues that bridge theoretical development with practical application are particularly interesting, to allow the presentation of both SAT's methodological contributions and its empirical validation through case studies from telecommunications, energy, and other sectors where the framework has been applied.

Conference participation represents another key dissemination channel for SAT's policy relevance. CyberSocial Lab. has presented SAT at major telecommunications conferences including EuCNC 2024 and 2025, where SAT's relevance to 6G development reached industry and research stakeholders directly involved in next-generation network deployment. Additionally, how SAT's multi-level approach contributes to scholarly debates about technology governance and societal engagement in innovation processes have been also presented at STS Italia Conference Milano innovation. These venues provide opportunities to demonstrate SAT's applicability across different disciplinary contexts, from technical telecommunications communities to social science researchers studying technology-society relationships, building awareness and credibility across the diverse stakeholder groups relevant to responsible 6G development. CyberSocial Lab. is planning to engage with these and further science and technology studies communities also in the future.

The timing and scope of publications will be determined by several factors currently under consideration, including the maturity of empirical findings from ongoing projects, opportunities for collaboration with academic partners who have applied SAT in their work, and strategic decisions about how to sequence different types of contributions, whether methodological papers, empirical case studies, comparative analyses with other frameworks, or policy-oriented articles translating SAT insights into practical recommendations.

Formats beyond traditional journal articles are also under evaluation, including extended conference papers, book chapters in edited volumes on technology ethics or responsible innovation, and potentially white papers or technical reports that can reach practitioner audiences more directly. The appropriate mix of publication types is being evaluated to balance academic credibility with practical impact.

Collaborative authorship with partners from universities and research institutions where SAT has been implemented represents an important dimension of our publication strategy that is currently being coordinated. These collaborations would strengthen the empirical base of publications and extend SAT's network within the research community, though specific arrangements are still being finalized.

Open access dissemination is a priority being integrated into our planning to ensure broad accessibility of research findings and compliance with funding requirements. The most effective channels for open access publication, including institutional repositories, preprint servers, and open access journal options, are under investigation, while managing associated costs through project budgets and institutional support where available.

This publication planning is ongoing and will be refined as opportunities emerge from current projects and as feedback is collected from initial dissemination activities. The strategy remains flexible to accommodate new collaborations, respond to calls for special issues or themed collections relevant to SAT's contributions, and adapt to evolving priorities within the research and policy communities we aim to engage.

3.1.1.7.2 Academic Partnerships

CyberSocial Lab. maintains ongoing collaborations with universities to advance SAT methodology and integrate acceptance research into academic training. Our engagement with the University of Rome "Tor Vergata" exemplifies this collaborative approach through participation in summer schools, workshops, and seminars where SAT's framework is presented to graduate students and early-career researchers. These teaching activities introduce SAT's conceptual foundations and practical applications to emerging scholars, positioning the framework within broader academic conversations about technology-society relationships.

An important dimension of our work is our internship programme, which offers students from law, social sciences, and philosophy fields the opportunity to gain hands-on experience working on Horizon Europe projects. These internships provide students with direct exposure to applied research in responsible innovation and technology assessment, bridging the gap between academic training and real-world research practice. Interns contribute to SAT-related activities including case documentation, literature review, stakeholder analysis and desk research, while developing practical skills in EU research project environments.

We are interested in formalizing these collaborations through more structured partnerships that could involve joint research initiatives, development of teaching materials, or regular integration of SAT into curriculum modules focused on technology ethics, innovation management, or applied social research. Such arrangements would strengthen both the academic grounding of SAT and its dissemination within education systems that train future technology professionals and researchers.

3.1.1.7.3 Integration with other Horizon or national projects

CyberSocial Lab. is actively integrating SAT into current and planned research projects as a methodology for assessing technology acceptance and aligning innovation with societal values. Within the SUSTAIN-6G project (Horizon Europe), the SAT framework is being applied to guide how 6G technology development can embed fundamental social values from early design stages. This involves stakeholder engagement activities, assessment of acceptance barriers across different vertical sectors, and translation of findings into design recommendations that address societal concerns alongside technical requirements. The SUSTAIN-6G application demonstrates the SAT's utility in shaping technology trajectories proactively rather than merely evaluating acceptance after deployment decisions have been made.

Looking ahead, we are positioning SAT as a core component in project proposals responding to Horizon Europe calls that emphasize responsible innovation, stakeholder engagement, or social impact assessment. This includes calls within the Smart Networks and Services Joint Undertaking, Digital Europe Programme, and thematic areas addressing AI ethics, smart cities, and green transitions where technology acceptance represents a critical success factor.

By establishing SAT's track record through projects like 6G4Society and SUSTAIN-6G, we aim to demonstrate its value to future consortia seeking robust methodologies for addressing social dimensions of technological innovation. We are also exploring opportunities within national funding programmes where technology acceptance assessment aligns with programme priorities for responsible innovation and societal engagement.

3.1.1.8 Policy

3.1.1.8.1 Expected contribution to policy thinking

The SAT framework has directly informed the development of 6G4Society's policy recommendations, serving as the analytical backbone for identifying governance gaps and societal risks in 6G development. Through systematic application of SAT's multi-level approach across project activities (citizen surveys, expert interviews, project documentation analysis, and SNS-JU community engagement), we have mapped the landscape of values at risk and governance deficits that require policy attention.

SAT's methodology helped to identify a clear pathway from empirical findings to actionable policy options. The framework helped to identify two critical concerns. Firstly, there are misalignments between Responsible Research and Innovation (RRI) principles and actual practices within the SNS-JU research. Second, specific societal values, privacy, inclusion, and technological sovereignty risk being marginalized in current 6G development trajectories. These concerns, elicited through SAT's analysis, were systematically examined to identify concrete risks, assess whether existing EU legal and policy framework adequately address these risks, and translate identified gaps into emerging policy needs.

This analytical process is documented in 6G4Society Deliverable D1.2 "Policy Brief: Towards a Socially Accepted and Sustainable 6G", and D1.3 "Operational Brief," where SAT provided the organizing logic for structuring recommendations around the values and concerns most salient citizens, experts, industry, and the research community. The framework demonstrates utility not merely as an acceptance measurement tool, but as a governance instrument that makes visible the relationships between technological choices, societal values, and policy adequacy.

3.1.1.8.2 Target audiences

- Policy Makers and Public Authorities: institutions and decision-makers responsible for shaping digital, innovation, and research policies, particularly in relation to ethical and societal dimensions of emerging technologies.
- Industry and Innovation Ecosystem: companies, startups, and R&D departments interested in integrating social values and assessment tools into their design, development, and deployment processes.
- Standardisation Bodies and Regulatory Organisations: entities involved in setting frameworks and standards for responsible and sustainable technology development.
- Civil Society and NGOs: organisations engaged in promoting ethical, inclusive, and human-centred innovation

3.1.1.9 IPR status

The SAT framework is the result of the research and innovation work carried out by CyberEthics Lab., a sister company of CyberSocial Lab., and developed through participation in several EU-funded projects. Within the 6G4Society initiative, CyberEthics Lab. initially contributed to the enhancement of the framework towards a 6G-customised SAT, informed by in-depth studies on socio-technical impacts and by feedback from external experts. During the course of the project, this role was progressively assumed by CyberSocial Lab., which now holds the rights to the further development and refinement of the SAT framework. This evolution was accompanied by active engagement in 6G SNS JU working groups and task forces, as well as by the continued participation of both organisations in other SNS JU projects.

3.1.2 KVI Ontology

3.1.2.1 Description & Innovation

3.1.2.1.1 Purpose and scope of the KVI Ontology

The 6G Key Value Indicators (KVI) Ontology is a semantic knowledge tool that has been developed under 6G4Society to provide a comprehensive, standardised, and semantically interoperable framework for representing the value aspect that underpins next-generation communication systems. Its purpose is to formalise a structured hierarchy as well as a shared vocabulary of Key Values (KVs) and KVIs, organically including their sustainability-oriented layer, Key Sustainability Indicators (KSIs), so that stakeholders across the 6G ecosystem can have a common reference point to consistently describe, assess and compare the non-technical impacts of 6G technologies.

At its core, the KVI ontology aims to standardise the understanding of 6G values and their associated indicators, addressing the current fragmentation observed across projects and research outputs. It acts as a consolidated knowledge base that structures knowledge into a unified machine-readable model that provides a semantically rich structure for aligning technological features with the value dimension. By offering this structure, it ensures transparency and traceability in how 6G socio-technical impacts are conceptualised and measured. It also supports evidence-based analysis of how technologies align with sustainability goals, including explicit connections to the UN Sustainable Development Goals. Beyond harmonisation, the ontology provides a basis for automated reasoning, enabling stakeholders to query indicators, explore relationships, detect trade-offs, and trace metrics back to high-level values.

The KVI Ontology organises its conceptual domain through a layered, hierarchical structure that captures the full pathway from high-level values to reported indicators. At the top level, it defines Key Values (KVs) as the fundamental societal, environmental or economic principles that 6G technologies are expected to uphold. Each Key Value is operationalised through one or more KVIs, which provide qualitative or quantitative measures of progress toward that value.

Beyond this hierarchy, the ontology models a rich set of semantic entities and relationships that describe how different features influence, depend on or inform one another. It establishes links that capture which indicators contribute to or measure a given value or express influence or relevance for particular actor groups. Together, these relationships support impact assessment and dependency analysis across the entire 6G value ecosystem, enabling users to understand how high-level principles translate into measurable outcomes and how different dimensions of value interact within socio-technical systems.

We note that the ontology's scope is designed to be dynamic and extensible, supporting updates as 6G evolves, accommodating new indicators, metrics, technologies, stakeholders, and regional contexts. These features (scalability, modularity and adaptability to regional priorities) are explicitly reported and taken into account in the Ontology's Requirement Specifications Document.

3.1.2.1.2 Innovation and comparative added value

The KVI Ontology marks a substantial step forward in how value-related aspects of 6G are structured and understood. Current work in the SNS JU landscape shows that KVIs are interpreted and applied in very different ways, with projects using their own definitions, levels of detail, and measurement approaches. This diversity reflects the richness of the ecosystem but also reveals the absence of a shared foundation. The ontology responds to this by introducing a semantic layer that provides a consistent, machine-readable structure for representing values and their associated indicators. In doing so, it moves beyond the project's KVI framework and offers a reference model that different actors can use to integrate their findings in a coherent and interoperable way.

The analysis of state-of-the-art frameworks is presented on Table 4. Existing white papers and surveys provide valuable insights, but they remain largely descriptive and disconnected from one another. The KVI Ontology brings these elements together by formally linking values, indicators and stakeholder perspective within a single reference model. This creates a shared language that supports alignment across projects and verticals, offers traceability from high-level principles to measurable evidence, and enables more transparent and grounded discussions about 6G's societal role. In this way it advances the project's developed KVI framework.

In comparative terms, the ontology delivers capabilities that neither traditional KPI-based frameworks nor project-level KVI taxonomies can offer. Whereas existing validation practices in 6G testing and trials tend to focus on performance-oriented metrics, the ontology enables multi-dimensional interpretation by integrating (particularly social) value viewpoints within a unified model. This is particularly relevant in conversations where verticals, industry domains, and stakeholder perspectives are concerned, where the need for value assessments that can accompany technical trials and reflect their specific expectations is highlighted.

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TABLE 4: STATE-OF-THE-ART FRAMEWORKS ANALYSIS

State-of-the-Art Framework	Current Role in 6G Research	Core Characteristics & Relevance
SNS TMV KVIs Survey White Paper (2025)[10]	Used as descriptive mapping of KVIs across SNS projects	Provides a consolidated list of values, KVIs and measurement approaches reported by SNS projects, but contains large variation across definitions, scopes, granularity and maturity levels.
6G White Paper on Validation and Trials for Verticals[11]	Vertical trials and KPI/KVI reporting practices	Highlights that KPI/KVI definitions differ significantly across verticals leading to non-comparable evaluation approaches and measurement fragmentation.
6G Indicators of Value and Performance[12]	Conceptual link between performance attributes & value impact categories	Proposes categories such as growth, efficiency and sustainability; focuses on business model transformation and value creation but lacks formal definitions for KVIs or structured modelling.
Hexa-X: 6G Vision, Value, Use Cases and Technologies[13]	High-level vision; defines key values & 6G drivers (sustainability, trustworthiness, inclusion)	Sets out the foundational values and directions for 6G research but does not operationalise how values map to indicators, metrics, use cases or measurement frameworks.
What societal values will 6G address? (6G White Paper - 6G IA SNVC WG)[14]	Defines initial societal value landscape for Europe, defines value pillars and socio-technical expectations	Discusses why 6G must embed societal and sustainability values; provides value categories and early rationale, but no unified system for structuring or querying them. Remains high-level and conceptual, without formal structuring or indicator hierarchies.

[10] Smart Networks and Services Joint Undertaking (SNS JU), "6G KVIS – SNS Projects Initial Survey Results 2025," 2025.
[11] A. Pouttu, *6G white paper on validation and trials for verticals towards 2030's,* University of Oulu, 2020.
[12] Ziegler, V., & Yrjola, S. (2020, March). 6G indicators of value and performance. In *2020 2nd 6G wireless summit (6G SUMMIT)* (pp. 1-5). IEEE.
[13] Hexa-X Consortium, "D1.1: 6G Vision, Use Cases and Key Societal Values," 2021.
[14] 6G-IA Societal Needs and Value Creation Sub-Group, "What Societal Values Will 6G Address? Societal Key Values and Key Value Indicators analysed through 6G use cases," 2022.

3.1.2.1.3 Integration with 6G4SOCIETY assets and SNS projects

The KVI Ontology is tightly integrated into the methodological and analytical backbone developed within WP3, which is laying out the value, KVI and KSI groundwork for 6G4Society. WP3's work has progressed through a bottom-up, consensus-driven approach involving SNS projects to build shared understanding of values, KVIs and sustainability requirements. The ontology functions as the structural anchor that consolidates this work: it provides the reference vocabulary, hierarchy and semantic relationships needed to formalise the Key Values, KVIs and KSIs emerging from WP3's thematic groups, consultations, and cross-project collaborations. This enables the theoretical models produced (including value typologies, stakeholder mappings, and RRI-oriented considerations) to be operationalised in a consistent, machine-readable format that can support traceability and transparency for future reuse. The ontology ensures that WP3's conceptual findings can be embedded into interoperable structures that other WPs and external actors can use in line with our overarching mandate.

Integration with SNS projects is also central to the ontology's purpose. 12 SNS JU projects have already been engaged in KVI-related activities. The unified model includes the ability to integrate project-specific KVIs from a multitude of SNS JU projects ranging across all 3 Calls, a mapping of technological enablers present in other initiatives, KPIs linkages, sustainability dimensions, stakeholder relevance, and domain-specific terminology. In practice the ontology is refined based on projects' insights, feeding from collaborative consensus activities, and incorporates a 6G use case taxonomy mapped to enable alignment with technical scenarios. These activities respond directly to recommendations for greater operationalisation and demonstrate tangible progress toward creating a backbone that can support testing, validation and impact assessments across SNS activities.

At programme level, the ontology also strengthens alignment with SNS Working Groups and pre-standardisation structures, building on 6G4Society's active participation in the SNVC WG, TMV WG, Sustainability Task Force and the Pre-Standardisation WG. In this way it is progressively becoming the semantic foundation through which the wider SNS community can converge on a shared value vocabulary and sustainability structure for 6G.

3.1.2.2 Target Users & Use Cases

The KVI Ontology is designed to serve a broad ecosystem of stakeholders involved in shaping, deploying, evaluating and governing 6G technologies. Its primary users include researchers and academic institutions employing the ontology to conduct interdisciplinary studies, benchmark findings across projects, and inform the evolution of KVIs and KSIs as new knowledge emerges. Policymakers who rely on structured value evidence to evaluate 6G deployments can assess sustainability contributions and align network developments with societal priorities. Industry actors and technology providers can use the ontology to understand how their solutions map onto key social values, and to monitor progress against agreed indicators. Designers and system architects benefit from the ontology's hierarchical structure to incorporate value-driven considerations into system design and environmental performance. In addition, standardisation bodies act both as users and validators, adopting the ontology as a reference vocabulary to harmonise value-related terminology and to support future standards that integrate sustainability and societal metrics.

Beyond these direct users, the ontology also benefits secondary stakeholders who depend on transparent, value-aligned technology development. Civil society organisations can apply the ontology to advocate for accountability, transparency and inclusivity in 6G initiatives, and to monitor impacts on vulnerable communities or specific societal groups. Likewise, European and national initiatives can use the shared value framework to assess how technology proposals align with policy priorities such as the European Green Deal and the UN SDGs, supporting funding decisions and long-term strategic planning.

3.1.2.3 Individual Exploitation Strategy
3.1.2.3.1 Academic Exploitation

The academic exploitation of the KVI Ontology focuses on consolidating its role as a reference model for value-driven 6G research and on ensuring that its methodological contributions reach relevant scholarly communities. The ontology's structure opens multiple avenues for academic publications across semantic technologies, telecommunications studies, sustainability assessment and socio-technical design. Planned outputs include journal articles and conference papers that document the ontology's design choices, its integration with cross-project KVI harmonisation, and its role in supporting sustainability-oriented analysis. In line with academic exploitation objectives, a dedicated Open Research Europe (ORE) publication is planned immediately after project closure, ensuring open-access dissemination and long-term visibility of the ontology as a scientific contribution.

To support broader uptake, a concise KVI Ontology fact sheet / white paper will be produced to provide an accessible description of the ontology, its core classes and its relevance for sustainability-aligned 6G development. Additionally, a practical step-by-step guide will be prepared to help researchers and engineers understand how to incorporate the ontology into their workflows, including instructions for querying value relationships, mapping project-specific indicators to the ontology and using the model in socio-technical evaluations. The guide is designed to support multidisciplinary use, making it relevant both for technical teams and for social science researchers studying technology-society interactions.

A key component of this roadmap is the planned handover of the KVI Ontology to the Sustain-6G project, where work on KVIs and sustainability indicators will continue in the coming years. This transition is being coordinated with the Sustain-6G team to ensure that the ontology can be taken up smoothly and incorporated into their ongoing modelling and use-case activities. The handover will involve depositing the ontology in a stable repository with a DOI, providing clear citation and user information, and organising dedicated sessions with Sustain-6G experts to walk through the model, its rationale and its intended applications. By engaging with Sustain-6G before 6G4Society ends, the aim is to ensure that the ontology can still shape the project's evolving KVI landscape and support a coherent continuation of the value-related work across the two initiatives. In the longer term, making the ontology openly accessible and well-documented is expected to support future Horizon Europe consortia seeking robust, shared tools for value-driven 6G research.

3.1.2.3.2 Policy & standardisation exploitation

The KVI Ontology has strong potential for policy impact and pre-standardisation uptake, particularly as European institutions and standardisation bodies seek structured ways to integrate sustainability, inclusivity and human-centric values into next-generation communication systems. Current discussions in forums such as 3GPP, ITU and ETSI remain dominated by performance metrics, architectural evolution and radio optimisation, with societal and environmental values appearing only marginally or as secondary considerations. The ontology aims to address this gap by translating abstract value commitments into a machine-interpretable model that provides a structured way of incorporating value dimensions in technology assessments. In doing so, it provides standardisation bodies with an operational tool for evidence-based regulation and supports the wider alignment of 6G development with the SDGs, the European Green Deal and the Digital Decade.

A central pathway for exploitation is the CEN Workshop Agreement (CWA) currently under development, which formalises a shared methodology and a minimum normative vocabulary for KVs and KVIs. The CWA introduces a value-flow ontology that structures the relationships between values, indicators, enablers, KPIs and stakeholders, and its publication will give the KVI Ontology institutional legitimacy as a recognised pre-standardisation instrument. This enables policymakers and standardisation groups to adopt a harmonised value framework and reporting approach while maintaining flexibility for sector-specific extensions. Because the CWA explicitly highlights the need for consistent structuring of societal and sustainability indicators, it positions the ontology as the first consolidated reference capable of supporting cross-project comparability and policy coherence across verticals. The ontology also provides direct operational value to standardisation groups by offering a common vocabulary and semantic backbone that can be referenced when assessing new technical features.

From a policy perspective, the KVI Ontology provides a practical instrument for translating high-level societal and sustainability goals into clear, actionable structures that regulators can use when evaluating 6G developments. Policymakers increasingly require tools that move beyond abstract principles and offer concrete ways to assess whether emerging technologies align with public values and long-term social priorities. The ontology supports this need by offering a consistent vocabulary and explicit mappings between values, indicators and technical enablers, enabling more transparent impact assessments and evidence-based decision-making.

3.1.3 KVI/KSI Framework

3.1.3.1 Description and innovation

The KVI/KSI framework addresses the need for Research and Innovation projects focused on sustainability to look beyond short-term efficiencies and target long-lasting, systemic change. It proposes a shift in impact measurement, from capturing value in the moment (Key Value Indicators, KVIs) to a dynamic assessment of long-term sustainability (Key Sustainability Indicators, KSIs). It helps projects to select and configure KVIs based on specific features that strengthen their connection to sustainability.

This approach addresses three persistent challenges in the PPDR technology landscape. First, it helps agencies prioritise solutions with demonstrable societal benefit, improving transparency and public accountability. Second, it enables technology providers to articulate and evidence the social value of their products, going beyond technical metrics. Third, it reorients innovation processes toward public-interest outcomes, even where budgets, procurement pathways, or market pressures might otherwise limit such considerations. The outcome is a shared, trusted evidence base that supports more legitimate and value-aligned technology decisions.

The Framework is a practical, stakeholder-driven methodology that supports both technology developers and public protection and disaster response (PPDR) decision-makers in selecting, designing, and evaluating innovations based on the values and needs of the communities they serve.

Rather than focusing solely on technical performance or cost, the framework uses a structured multi-stakeholder dialogue to identify key social values, such as reducing harm, improving fairness, and strengthening public safety, and translates them into measurable indicators that can guide technology choices and track societal impact over time. The methodology is supported by practical tools and capacity-building resources, including:

- A structured set of PPDR-relevant social values and definitions,
- Step-by-step guidance for identifying and assessing societal impact,
- A replicable method for deriving Key Value Indicators,
- Training materials enable organisations to adapt and maintain the process according to their local context and operational needs.

3.1.3.2 Target Users

The primary users of the KVI/KSI Framework are organisations involved in the development, procurement, and governance. These include:

- **Public Safety and Disaster Response Agencies**: Police, fire services, ambulance services, and emergency management organisations that require transparent, evidence-based methods to justify technology investments and demonstrate accountability to the communities they serve.
- **Technology Developers and Solution Providers**: ICT companies offering public safety solutions that need to differentiate their products beyond technical features and demonstrate societal value to strengthen their competitiveness in procurement processes.
- **Government Procurement and Policy Bodies**: Municipal, regional, and national authorities responsible for technology purchasing and policy oversight who must ensure responsible, defensible, and socially aligned investment decisions.

Within these groups, two distinct roles emerge: Adopters/Decision-Makers (e.g., procurement officers, innovation leads) who decide whether the methodology is implemented. Operational End-Users (e.g., IT coordinators, user-research staff) who apply the framework in practice, facilitate dialogues and generate evidence.

3.1.3.3 Use cases benefiting from the KER

The methodology is delivered through services, training, and consultancy, with the long-term aim of establishing a self-sustaining model. Typical use cases include:

- **Facilitating multi-stakeholder** dialogues to identify shared values, priority outcomes, and evidence needs in technology projects.
- **Supporting users during procurement** by providing structured societal impact assessments, enabling clearer justification of investments.
- **Assisting technology companies** in demonstrating how their solutions contribute to societal goals using standardised, stakeholder-validated indicators.
- **Capacity-building programmes** from introductory workshops to in-depth training for certified practitioners.
- **Development of a future digital management tool** to document decisions, values, definitions, indicators, and evidence across the full process.
- **Recognition and endorsement mechanisms**, such as a value-based "stamp" for organisations or products that complete the process.

These use cases strengthen organisational transparency, improve technology alignment with societal needs, and enhance trust among communities, agencies, and solution providers. To achieve these results, we collaborated closely with a wide range of PPDR stakeholders as well as partners from the Beyond 5G/6G project community. Our framework was presented and evaluated during events such as the PSCE Spring 2025 conference, where we engaged with numerous PPDR stakeholders, including policy makers, industry leaders, technology developers, and first responders. Similarly, parts have been shared and evaluated with SNS-JU projects to understand how it might be possible to constructively define the relationship between key values, stakeholders, their pain points and desired impacts in order to derive indicators. Their feedback proved invaluable: the discussions, demonstrations, and practical testing sessions enabled us to further refine, adjust, and enhance the framework, as well as our understanding of the values. This iterative process helped ensure that the final version is as robust, practical, and relevant as possible for real-world operations. It also supported us in identifying necessary ongoing improvements.

3.1.3.4 Individual Exploitation

To transition the project methodology into a sustainable, revenue-generating service and training offering, within the PPDR domain, the exploitation will focus on three main areas:

- Formalizing the methodology into a comprehensive, repeatable service/training model.
- Defining the value proposition, business plan, and pricing through direct user engagement.
- Ensuring IP is protected and establishing a plan for long-term maintenance and revenue.

3.1.3.5 Initial Market Engagement

3.1.3.5.1 Market Focus

The PPDR (Public Protection and Disaster Relief) domain will be the initial focus, targeting stakeholders with strong needs to demonstrate societal impact:

- Research Consortium Leaders & Project Coordinators facing pressure to demonstrate broader impact in grant applications
- Innovation Managers at Emergency Service Agencies responsible for justifying technology spending
- PPDR Technology Companies seeking competitive advantage through credible societal value demonstration

3.1.3.5.2 Channels and Initial Actions

- PSCE Network: Direct outreach for pilot implementations and feedback
- EU Project consortia: Offer methodology as a specialized service for impact assessment requirements
- Conferences: Promote service through talks and introductory training workshops at PSCE conferences
- EC Networking: Engage key actors to expand reach beyond PSCE membership.

<u>Phase 1: Validation and Prototype Refinement (0–1 year post-project)</u>

Pilot the methodology with R&I teams to refine resources and develop high-quality documentation. Clarify the USP and conduct feedback loops. Articulate a preliminary business plan, including implementation costs, revenue sources, and branding potential (e.g., "Tested by PSCE" certification).

<u>Phase 2: Business Maturation and Deployment (1-3 years post-project)</u>

Formalize the service with defined resource plans and pricing. Investigate the establishment of IP/IPR protection through licensing/trademark and the development of the service prototype and explore digitalisation opportunities (e.g., management platform) and necessary certifications.

3.1.3.6 IPR Status

The KVI/KSI framework represents the culmination of extensive research, innovation, and community engagement conducted by PSCE. Its development has been progressively shaped through active participation in, and the valuable feedback gathered from, several EU-funded projects. Throughout the duration of the 6G4S project, PSCE played a central role in advancing the framework, steering it toward a version specifically adapted to emerging 6G requirements. This evolution was guided not only by comprehensive studies on socio-technical impacts, but also by continuous input from external experts and practitioners who contributed to validating and enriching the framework's direction.

Over the course of the project, PSCE increasingly took ownership of the conceptual and methodological development of the framework. Today, PSCE holds the rights to continue enhancing, updating, and refining the KVI/KSI framework, ensuring its long-term relevance and its capacity to support next-generation communication systems and public safety stakeholders.

PSCE brought to the project the KVI/KSI Framework as a background, and the result of the work developed during the project will remain the sole ownership of PSCE (foreground).

3.1.4 Policy Briefs and Operational Briefs

3.1.4.1 Description and Innovation

The Policy Briefs and the Operational Briefs constitute eight structured and actionable documents designed to translate the project's research findings into clear strategic messages for policymakers, public authorities, standardisation bodies and industrial stakeholders. It synthesises complex evidence, methodological insights and stakeholder feedback into concise recommendations and options, offering a practical instrument capable of supporting informed policy and industrial 6G technology design and facilitating the uptake of project outcomes beyond the project's duration. By presenting validated results in an accessible format, the two briefs strengthen the link between scientific analysis and real-world governance and industrial technology implementation.

Their innovative value stems from the way they merge scientific evidence with the participatory insights collected throughout the project. The briefs draw on validated methodologies, multi-stakeholder co-creation activities and empirical results derived from quantitative surveys, qualitative interviews and workshops, as well as extensive desk research. This ensures coherence and robustness across citizen, expert and institutional perspectives. The comprehensive combination of scientific literature, citizen surveys, participatory sessions, interviews with industry practitioners and specialists in acceptance, 6G, green ICT, smart cities and sustainability, together with policy consultations and exchanges within the SNS JU community, brings together complementary academic, civic and institutional viewpoints. This integrated approach strengthens the legitimacy, transferability and policy relevance of the recommendations.

As a result, the two briefs act as a distinctive tool for bridging research, policy and practice, offering a forward-looking mechanism for sustaining and amplifying project impacts and 6G technology acceptance.

3.1.4.2 Target Stakeholders

The primary users of the Policy Briefs are policymakers at local, regional, national and European levels, as well as research program funders and public-private partnerships established to support research, innovation and deployment (e.g., SNS JU), as well as public administrations seeking guidance for strategic planning or regulatory development. Standardisation bodies, industrial players, research organisations, think tanks and civil-society actors may also benefit from the brief, both as a reference for evidence-based advocacy and as a basis for further analytical work.

The Operational Briefs are more targeted to industrial players in 6G technology (e.g., network operators, telecommunications vendors, device manufacturers, services and infrastructure providers) to anticipate trends, adjust strategic orientations accordingly, specifically on 6G technology design, implementation and deployment.

3.1.4.3 Use Cases and Scenarios

The Policy Briefs are designed for use in policy development processes, strategic foresight exercises, research and innovation programmes design, standardisation efforts and evaluation activities. Its recommendations support decision-makers facing complex transitions, such as digital transformation, sustainability challenges or socio-economic restructuring.

The Operational Briefs are designed for actors directly involved in the design, implementation and deployment of 6G technologies. It serves industrial stakeholders such as network operators, telecommunications vendors, device manufacturers, services and infrastructure providers who require timely, evidence-based insights to inform technical roadmaps, investment priorities and innovation strategies. Its guidance supports organisations navigating rapidly evolving technological landscapes, helping them to align research activities, anticipate market shifts and respond effectively to emerging standards, deployment requirements and sustainability and acceptance expectations within the 6G ecosystem.

During the project, the content of the Policy Briefs was tested and refined through interactions with targeted stakeholders, ensuring that its messages respond to real governance needs and reflect diverse operational contexts. This grounding in practice enhances the credibility of the Policy Briefs and increases the likelihood of its adoption in future policy agendas.

3.1.4.4 TRL and next steps for readiness

The Policy Briefs and the Operational Briefs are conceived as living documents. At this stage, they have reached a high TRL and are ready to be disseminated to their respective target stakeholders. Nonetheless, their content is continuously monitored and updated to keep pace with the evolving regulatory, political, societal and technological landscape of the 6G ecosystem.

3.1.4.5 Academic Roadmap

3.1.4.5.1 Plans for research publications

The academic dissemination strategy for the Policy Briefs and the Operational Briefs are being developed as part of a broader effort to ensure that the conceptual foundations, methodological processes and empirical insights behind these documents contribute meaningfully to ongoing scientific community debates. Both briefs synthesise findings from interdisciplinary research carried out within 6G4Society and previous initiatives, making them strong candidates for publication formats that bridge technology studies, telecommunications research, policy analysis and innovation governance.

The interdisciplinary nature of the work combining social science inquiry, participatory methods, and policy analysis, shapes the approach to academic dissemination. Potential publication venues spanning innovation studies, communications policy, science and technology studies, digital governance, and future networks research are being assessed to maximise academic impact. Journals and conferences that emphasise the interplay between technological development and societal expectations are of particular interest, as they allow the project’s methodological contributions, co-creation processes and policy insights to be fully articulated.

Target journals are being identified based on their relevance to emerging debates around 6G governance, participatory technology assessment, digital transformation, and sustainable and acceptance innovation pathways, as well as their potential to reach policymaking and practitioner communities.

Conference participation continues to play a central role in academic dissemination. Presentations at major telecommunications and digital policy events, such as EuCNC/6G Summit, sectoral innovation conferences and relevant STS or policy-oriented academic gatherings, have already demonstrated the relevance of the briefs' underlying research to diverse audiences. These venues offer valuable opportunities to engage directly with researchers, industry experts and policy actors involved in next-generation network governance, helping to build awareness, credibility and dialogue across communities.

The timeline and structure of forthcoming publications will depend on several factors, including the maturation of empirical analyses, emerging opportunities for joint authorship with partners, and strategic considerations on how to sequence contributions. Possible outputs range from methodological articles examining the integrated research approach underpinning the briefs, to empirical papers exploring citizen, industry and policymaker perspectives on 6G, to policy-oriented pieces translating findings into actionable recommendations. Additional formats such as extended conference papers, book chapters on digital governance or responsible innovation, and practice-oriented white papers are also under consideration to reach a broader professional audience.

In addition to journal articles and conference contributions, plans are also underway to explore the possibility of developing a publication in collaboration with STOA (Science and Technology Options Assessment) of the European Parliament. Given STOA's role in providing independent scientific and technological analysis to support evidence-informed policymaking, a dedicated STOA publication would represent an impactful channel for disseminating the insights emerging from both the Policy Briefs and the Operational Briefs to high-level institutional audiences.

To pursue this objective, CyberSocial Lab. intends to undertake the necessary preparatory steps, including identifying suitable STOA study formats, aligning the thematic focus of the briefs with STOA's ongoing priorities, and engaging with relevant parliamentary contacts to assess feasibility. This process may involve submitting an expression of interest, contributing to preliminary scoping discussions, or collaborating with STOA's scientific advisers and external experts. Securing such a publication would significantly enhance the visibility and policy influence of the project's research outputs within the EU legislative sphere.

This publication strategy is iterative and will evolve as additional evidence emerges, collaborative opportunities develop and new calls for themed issues or interdisciplinary collections arise. The approach remains intentionally flexible to reflect the evolving technological and policy context surrounding 6G.

3.1.4.5.2 Academic Partnerships

Academic partnerships play an essential role in consolidating and extending the research foundations of the Policy Briefs and the Operational Briefs. Collaborations with universities, research institutes and centres specialising in telecommunications, innovation studies, digital governance and social science research are being reinforced to support co-authored publications, comparative analyses and methodological development. Joint work with partners involved in further EU projects, such as for instance SUSTAIN-6G (Horizon Europe), will enable the integration of diverse empirical perspectives, strengthening the academic credibility and applicability of resulting outputs. Ongoing dialogue with these partners will continue to shape future research directions, enhance the briefs' evidence base and situate the project's findings within broader European research ecosystems.

3.1.4.5.3 Integration with other Horizon or national projects

CyberSocial Lab. is a partner of SUSTAIN-6G projects (Horizon Europe), which provides a natural platform for extending, validating and refining the research foundations that underpin both the Policy Briefs and the Operational Briefs. The collaboration across multiple Horizon Europe initiatives ensures that the insights derived from the 6G4Society project are not isolated but instead feed into a broader, interconnected research ecosystem addressing sustainability and acceptance of next-generation networks.

Beyond this ongoing collaboration, CyberSocial Lab. is actively exploring opportunities to integrate its work into other EU-funded and national initiatives focused on digital transformation, responsible innovation and advanced communication systems. This includes engaging with project consortia working on green ICT, smart cities, digital inclusion and regulatory innovation, where the approaches developed for the Policy Briefs and the Operational Briefs can provide added value. Participation in proposal consortia for upcoming Horizon Europe calls, as well as national funding schemes, will further expand the CyberSocial Lab.'s capacity to apply and test the methodological insights, stakeholder frameworks and policy guidance emerging from the project.

3.1.4.6 Policy

3.1.4.6.1 Expected contribution to policy thinking

The Policy Briefs and the Operational Briefs are expected to make a substantive contribution to policy thinking by providing evidence-based, stakeholder-informed insights that clarify the societal, regulatory and technological implications of 6G development. By integrating empirical findings, participatory perspectives and cross-sectoral expertise, the briefs support policymakers in navigating the complexity of next-generation networks and in anticipating emerging governance challenges. They offer actionable guidance for embedding societal expectations, sustainability and acceptance objectives and ethical considerations into regulatory frameworks, research and innovation programmes design, standardisation efforts and strategic foresight activities. Through this contribution, the briefs aim to strengthen policy coherence across European initiatives, promote responsible innovation pathways, and enhance the preparedness of institutions tasked with shaping the future 6G landscape.

3.1.4.6.2 Target audiences

- Policy Makers and Public Authorities: institutions and decision-makers responsible for shaping digital, innovation, and research policies, particularly in relation to ethical and societal dimensions of emerging technologies.
- Industry and Innovation Ecosystem: companies, startups, and R&D departments interested in integrating a social perspective into their design, development, and deployment processes.
- Standardisation Bodies and Regulatory Organisations: entities involved in setting frameworks and standards for responsible and sustainable technology development.
- Civil Society and NGOs: organisations engaged in promoting ethical, inclusive, and human-centred innovation.

3.1.4.7 IPR status

The Policy Briefs and the Operational Briefs are both results of the activity of CyberSocial Lab. into the 6G4Society project within project task 1.4.

3.1.5 Knowledge Transfer Framework on Technology Acceptance and Social Sustainability Values in 6G

Co-created in collaboration with three partners, the framework combines the SAT framework, the Key Value Indicators (KVIs) and the KVI Ontology of social sustainability values. This Knowledge Transfer Framework aims at facilitating the understanding, measurement, and operationalisation of social acceptance in 6G technology development, embodying the capacity to translate complex social science knowledge into actionable insights for engineering and innovation ecosystems. It leverages three pillars of competence and experience:

- first, over two decades of consolidated expertise in traditional innovation processes, enabling structured approaches to stakeholder engagement and knowledge transfer;
- second, two years of direct involvement in the 6G4Society project, through which the consortium has built an extensive network within the 6G community, including researchers, standardisation bodies, industry representatives, and policy actors;
- and third, a unique interdisciplinary integration of social sciences and engineering, allowing for a comprehensive analysis of the socio-technical dimensions of 6G.

By focusing on the **acceptance of technology as a social process**, this Knowledge Transfer Framework redefines a typically engineering-driven challenge through a social science lens. It decomposes the issue of acceptance into its value-based components, KVIs Ontology reconstructing it as an iterative process of co-design between technology developers and society. The inclusion of KVIs and KVI ontology allows stakeholders to identify, measure, and navigate societal values thereby aligning technical innovation with shared societal goals.

A core strength and **unique selling point** of this KER lies in its **capacity to** provide a structured, evidence-based method to communicate social insights in the language of engineers, network operators, policymakers, and other technical actors. This makes it a **strategic enabler for responsible innovation**, helping clients to integrate social sustainability from the earliest design phases rather than retrofitting it post-development. Through early narrative construction, the framework ensures that technological innovation is not only efficient and cutting-edge but also legitimate, desirable, and value-aligned.

Currently, it is intended as a transferable asset to other EU-funded 6G initiatives, with particular relevance to the Sustain-6G Lighthouse project, where it supports the co-creation of technology in alignment with societal values and user acceptance dynamics.

It holds a potential for commercial exploitation: by transforming research outputs into actionable frameworks and tools, the partners can position themselves as **trusted intermediaries** between social sciences and technical stakeholders, offering a unique service line that enhances both the legitimacy and competitiveness of 6G technologies developed in Europe.

3.1.5.1 Market Segment, Potential Stakeholders and Services

If developed as a **commercial collaboration** among the 6G4Society partners that developed the SAT, the KVIs framework and the KVI Ontology, the Knowledge Transfer Framework could be offered as a **specialised offering** to the broader 6G ecosystem.

A **market segment for this offering would lie within the European 6G innovation** ecosystem, encompassing both research and early deployment phases of next-generation communication technologies. This includes **standardisation and regulatory bodies, research and innovation (R&I) consortia, and public authorities** responsible for shaping digital, social, and sustainability policies.

A **parallel market segment would include the telecommunication sector**, specifically **telecommunication operators, network infrastructure providers, and technology vendors**. For these stakeholders, the framework provides both strategic and operational benefits: it reduces the risk of societal resistance, enhances compliance with EU value-based innovation principles, and strengthens stakeholder alignment in large-scale technology rollouts, with the integration of social sustainability and responsible innovation principles into technological development pathways.

Within this market, the Knowledge Transfer Framework could evolve into a portfolio of **specialised knowledge-based services** composed by:

- Advisory services on technology acceptance and value-driven innovation strategies, helping organisations embed social sustainability criteria into their R&I or deployment processes.
- Training and capacity-building modules designed to familiarise engineers, policymakers, and innovation managers with social science approaches to technology development and with the use of KVIs and value ontologies.
- Assessment and benchmarking tools supporting the evaluation of social acceptance readiness and alignment with EU value-based innovation frameworks.
- Facilitated knowledge transfer sessions and workshops that enable cross-disciplinary dialogue between social scientists, engineers, and network operators, fostering shared understanding and co-design capacities.
- Narrative and communication design support, aimed at shaping value-aligned technology narratives from the earliest stages of system conception and stakeholder engagement.

Together, all these specialised knowledge-based services would address the growing demand in the 6G domain for structured, evidence-based approaches to responsible innovation and social sustainability.

3.2 Knowledge, Dissemination & Engagement

The 6G4Society project placed strong emphasis on knowledge sharing, stakeholder engagement, and accessible dissemination throughout its lifecycle. To achieve this, the project leveraged multiple digital platforms and formats to ensure wide visibility and long-term access to results.

The 6G4Society website served as the main public-facing knowledge hub. It features the project's vision, activities, and resources, including news updates, public deliverables, event announcements, and downloadable educational materials such as the "What is 6G?" information package (available in multiple languages). The website will remain online for at least two years beyond the project end to support continued access to these materials.

In parallel, the **6G4Society YouTube channel** was used to publish high-quality video content, including expert interviews, webinar recordings, and explainer videos. These audiovisual assets contributed to both outreach and knowledge translation, making technical content more accessible to wider audiences.

All relevant publications and open-access materials are archived on **Zenodo** to ensure long-term availability. These include public deliverables, the Insight Reports series, academic contributions, the KVI/KSI framework, and documentation related to the Social Acceptance of Technology (SAT) model.

To broaden participation and foster dialogue, the project launched the **6G4Society Community Forum on LinkedIn**, a discussion-based group designed to engage stakeholders, from researchers and policymakers to citizens and civil society, on the societal dimensions of 6G. This forum remains active and will serve as a legacy space for ongoing discussion beyond the project's completion.

In addition to publishing content online, 6G4Society presented its insights at key EU events and thematic conferences, such as Sustainable Places, EuCNC, and ACM GoodIT, enabling other projects and stakeholders to reuse or adapt its frameworks. These activities served as knowledge transfer points for concepts like KVIs, social acceptance, and sustainability in 6G.

Through participatory workshops and dialogues, the project also gathered feedback that fed into its tools, contributing to their future relevance and adaptability across different use cases.

3.2.1 Generated Knowledge

A key output of the project is a public-facing information package designed to make 6G understandable and relatable for non-experts. Its purpose is to translate technical research into accessible learning materials that explain how 6G works and why it matters for society. The resources aim to support quick comprehension, encourage engagement and serve as reusable communication tools for awareness and outreach.

The package contains a series of infosheets that present the societal and practical dimensions of 6G in short, approachable explanations. Each sheet focuses on one theme, which allows readers to explore the topic in a clear and structured way.

Infosheets included in the package:

- *What is 6G? Introduction to key concepts, the evolution from 5G and expected impact.*
- *What's in it for me? How 6G may influence daily life, services and digital interactions.*
- *Transforming learning with 6G Applications in education, remote learning and skill accessibility.*
- *6G and Smart Cities The role of 6G in sustainable cities, transport and connected infrastructure.*
- *6G for Accessibility: Inclusion through Technology How 6G could improve inclusion and access for a wider population.*

In addition to the infosheets, the information package includes an animated explainer video titled "**What is 6G?**". This video provides a fast and visually engaging introduction to the topic and is suitable for audiences who need a simple and clear starting point. Through concise narration, motion graphics and everyday examples, it conveys the core ideas of 6G in an accessible way and complements the more detailed written materials.

Together, the infosheets and the animated video form a coherent knowledge package that lowers the entry barrier for public understanding and supports wider participation in the conversation about future connectivity.

3.3 JOINT EXPLOITATION

As part of the joint exploitation dimension of 6G4Society, two Key Exploitable Results (KERs) have been conceptualised: the Competence Centre and the Pool of Experts (HUB). While these initiatives were not initially foreseen in the Description of Action (DoA) and no dedicated resources were allocated for their development during the project's lifetime, they emerged organically through project discussions as valuable mechanisms for ensuring long-term impact and sustainability of project outcomes. This chapter outlines preliminary feasibility assessments for both initiatives and their potential as future legacy structures.

3.3.1 Competence Centre (Feasibility Study)

The concept of a 6G4Society Competence Centre emerged during the second year of the project as a potential sustainability mechanism capable of ensuring long-term access, use and further development of the project's outputs. Although not originally foreseen in the Grant Agreement and therefore not funded or developed during the project implementation, the

Competence Centre represents a natural evolution of the project's role within the wider SNS JU ecosystem. It builds on the project's foundational work on social acceptance, sustainability, ethical value frameworks and stakeholder-facing knowledge tools and represents a structure that could strengthen impact well beyond the project's duration.

3.3.1.1 Objective

The main objective of the Competence Centre will be to preserve, curate and operationalise the knowledge generated within 6G4Society, while also providing a space for continuous learning, advisory support and knowledge exchange among researchers, policymakers, industry actors and civil society stakeholders concerned with the social dimensions of 6G. Today, no single European entity is dedicated to combining insights on acceptance, sustainability, governance, and key value indicators for next-generation networks. The Competence Centre could fill this gap by acting as a reference point for both technology development and policy reflection.

3.3.1.2 Mission

The mission of the Competence Centre would be to ensure that the tools, frameworks, methodologies and insights generated throughout 6G4Society remain accessible, usable and relevant. This includes the SAT Framework, KVI Ontology, KVI/KSI Framework, policy and operational briefs, insights and stakeholder engagement methodologies. Beyond preservation, the Competence Centre would also aim to actively support capacity building, through activities such as webinars, training modules, advisory services and policy consultations, while encouraging cross-project dialogue and accelerating future innovation in line with EU values.

3.3.1.3 Target Stakeholders and Users

The Competence Centre would serve a diverse set of audiences, including:

- policymakers and regulatory authorities responsible for spectrum policy, digital rights, AI governance and infrastructure planning
- SNS JU projects requiring validated frameworks for value-based assessment or societal impact modelling
- standardisation and pre-standardisation bodies seeking structured input from social sciences
- private-sector actors developing 6G technologies who require guidance on ethics, trust and acceptance topics
- academic and research communities exploring non-technical dimensions of future networks.

3.3.1.4 Potential Functions and Services

The Competence Centre is envisioned as an entity that will not only host knowledge but also activate it. Its functions could include the maintenance and update of project assets (such as the SAT Framework and KVI Ontology), provision of advisory services to future digital infrastructure projects, facilitation of capacity-building and training tailored to public authorities or R&I communities and structured support for policy development through evidence-based briefs and consultation processes. An additional key function would be to act as a bridge between technical and social innovation within the 6G ecosystem, ensuring that socio-technical values remain central.

3.3.1.5 Feasibility Considerations

Since the Competence Centre was not planned within the initial project scope, no resources or technical integration work have been allocated. Therefore, any feasibility pathway must consider a phased approach. The most realistic short-term model would be the creation of a virtual Competence Centre, hosted by one or more partners, leveraging existing infrastructure (e.g. project website) and requiring only a moderate level of effort to maintain. This would allow the knowledge produced to remain visible and usable in the SNS community without demanding immediate institutionalisation.

A medium-term scenario would involve embedding the Competence Centre within an already established legal entity such as a research institute, competence cluster or innovation network, thereby gaining access to administrative, operational, and financial support. The long-term scenario would involve creating a fully independent legal structure with its own governance, funding streams, and strategic roadmap. While this option offers strong sustainability potential, it would require sustained funding and a clear governance structure.

3.3.1.6 Governance Model

Initially, the Competence Centre could be coordinated by a small operational nucleus consisting of 1-2 partners of the 6G4Society consortium. This lightweight governance would remain in place during an interim period while assessing interest from external stakeholders, mapping funding opportunities and formalising future partnerships. As the Centre evolves, a more robust governance model could be established, for example through a board of stakeholders representing research, industry, policy and civil society perspectives.

3.3.1.7 Funding and Sustainability Pathways

Since no direct funding is available at present, the Competence Centre would require a diversified funding model. In the short term, its operation could be explored through lightweight mechanisms, potentially integrated into ongoing or upcoming EU-funded initiatives, particularly within future SNS JU calls. Mid-term funding opportunities may be pursued under Horizon Europe (especially CSA calls), the Digital Europe Programme, or national digital transformation schemes that support capacity building, training, or the development of research infrastructures. In the longer term, sustainability could be achieved through a mixed funding model, combining public funding streams with private-sector support, consultancy-based services, or membership schemes tailored to stakeholder needs.

3.3.1.8 Future Implementation and Sustainability Prospects

As the 6G4Society project concludes, the Competence Centre remains at a conceptual and structural definition stage, with this deliverable serving as the first formal articulation of its mission, purpose and feasibility pathway. While no operational or implementation activities have taken place, as those were not foreseen in the project scope, the groundwork laid here provides a strong foundation for future development.

Although the Competence Centre cannot be realised within the existing project timeframe or budget, it remains a compelling legacy opportunity that is well aligned with SNS JU strategic goals. Its realisation will depend on securing resources, engaging stakeholders and establishing the necessary governance and hosting infrastructure.

3.3.2 Pool of Experts (HUB)

The concept of a 6G4Society Pool of Experts (referred to as the HUB) has been introduced as a complementary sustainability mechanism to the Competence Centre. While the Centre focuses on preserving and activating knowledge assets, the HUB aims to sustain the human capital and multidisciplinary expertise mobilised throughout the 6G4Society project. Although not included in the original Grant Agreement and not resourced for implementation within the project's timeframe, the HUB presents a valuable forward-looking action to enhance long-term impact.

3.3.2.1 Objective:

The primary objective of the Pool of Experts is to create and maintain a curated, dynamic directory of professionals and researchers who are able and willing to offer their expertise on the socio-technical dimensions of 6G design, governance and implementation. This includes topics such as trust, inclusion, ethics, sustainability, acceptance and policy alignment, areas where specialised insight is often required to support projects, public authorities and regulatory bodies.

3.3.2.2 Potential Functions and Benefits:

The Pool of Experts would serve as a matchmaking platform between expertise and real-world needs, offering several direct benefits:

- **Support for future SNS JU projects** in identifying advisors or contributors for use-case development, social impact assessment, stakeholder engagement or value alignment activities.
- **Contribution to policymaking processes**, consultations and white paper development on topics linked to spectrum governance, digital inclusion and societal readiness.
- **Knowledge diffusion and continuity**, enabling 6G4Society's legacy to persist through the active involvement of its contributors in future initiatives.
- **Capacity-building and mentorship**, by providing early-stage projects or smaller consortia with access to senior experts from the 6G4Society community.

3.3.2.3 Feasibility Considerations:

As with the Competence Centre, the Pool of Experts remains a conceptual proposal, and no implementation work has been conducted during the project. A lightweight, virtual model is considered the most feasible path forward in the short term.

- **Operational status**: No registry, database or interface currently exists. The concept is being documented here for the first time.
- **Hosting and governance**: The hosting and coordination of the HUB would need to be carefully considered, as the required infrastructure and operational needs may go beyond a minimal setup. One potential pathway could involve integration into existing digital platforms, such as the SNS JU portal or future project websites. However, this would depend on the availability of resources and alignment with the objectives of those platforms. Since no budget has been allocated within 6G4Society for the implementation of this concept, its future realisation would likely require external funding or uptake through other projects.
- **Maintenance and GDPR**: Any registry would need to comply with data protection regulations and include mechanisms for regular updates, opt-ins, and access control.

A basic structure could consist of:

- A list of thematic domains and expertise areas
- Contact mechanisms (e.g., anonymised matchmaking or centralised enquiry)
- Voluntary profiles of individuals and their affiliations
- A contact person or admin entity to maintain the hub

3.3.2.4 Sustainability and Integration Pathways

The viability of the Pool of Experts depends largely on future project uptake or integration within broader community efforts. Three realistic pathways have been identified:

1. **Inclusion in upcoming SNS projects** (e.g., Sustain-6G or other CSA-type initiatives), where the HUB could be developed as a work package output with dedicated budget and staff.
2. **Embedding into an existing research infrastructure or competence network**, such as those operated by academic institutions, think tanks, or European Technology Platforms.
3. **Integration into the Competence Centre**, where the HUB would act as a human resource counterpart to the knowledge repository, supporting requests, offering consulting services and acting as ambassadors of 6G values.

In all cases, further work is needed to:

- Map existing expert networks and relevant platforms
- Confirm the interest of 6G4Society participants to remain involved post-project
- Assess GDPR-compliant hosting options
- Identify potential funding schemes (e.g., Horizon Europe CSA calls, Digital Europe Programme)

3.3.2.5 Conclusion and Recommendations

The Pool of Experts is a feasible, low-barrier initiative that can amplify the impact of 6G4Society's work by preserving and reactivating the expertise built during the project. Its operationalisation requires minimal funding, but some effort in terms of hosting, curation and engagement. The next step would be to pilot a small version of the registry, perhaps embedded within the Competence Centre or project website and explore opportunities for expansion through future SNS projects. If implemented thoughtfully, the HUB could serve as a critical link between the research community, policy stakeholders, and future innovators, ensuring that social and ethical perspectives remain embedded in the 6G development process.

4 STANDARDISATION

4.1 KVI ONTOLOGY

4.1.1 DESCRIPTION, OBJECTIVES AND INNOVATION OF THE KVI ONTOLOGY

The 6G Key Value Indicators (KVI) Ontology was developed to provide a unified, transparent, and semantically consistent framework for describing value and sustainability concepts in the 6G ecosystem. As detailed in its Ontology Requirements Specification Document (ORSD) [1], the ontology's mandate is to standardise how Key Values and their indicators are defined, measured, and related to technology, stakeholders, and use cases across the SNS JU research landscape.

There has been identified a growing need for a shared vocabulary capable of aligning 6G design, evaluation, and policy outcomes with European value-based priorities. Based on research insights, there is also currently a lack of coherent mechanisms to connect values to technical artefacts and evidence across SNS projects. More specifically, despite all SNS JU projects operating under the same high-level European vision for 6G, their involvement and reporting of values, KVIs, and supporting evidence is highly fragmented. This fragmentation is structural. It arises from differences in mandate, maturity, and primary research focus, which naturally lead to inconsistent terminology, priority-setting, and methodological approaches.

First, SNS projects span a wide range of TRLs, from early-stage conceptual work to late-stage experimental validation. Lower-TRL projects typically articulate values at a theoretical or exploratory level, usually reporting broader statements on inclusion, sustainability, or trust, whereas higher-TRL projects define KVIs only where they support concrete trials, KPIs, and measurable outcomes. This creates uneven granularity, as some projects provide structured indicators with metrics and targets, whereas others offer qualitative descriptions or skip KVIs entirely.

Second, projects have different mandates and therefore emphasise different value dimensions. Technology-driven projects prioritise value concerns, such as safety, as technical qualities, while vertical-oriented projects emphasise societal impact, quality of life, or economic gains. Because values are not mandated uniformly across SNS calls, each consortium frames them according to its specific objectives and stakeholder expectations.

A third and important issue is that values are often treated as secondary considerations rather than primary design drivers, which is especially prominent in standardisation work. In several projects, values enter the discussion only late in the pipeline, typically aligned with impact sections or ethical assessments, rather than shaping architecture or evaluation frameworks from the outset. As a result, the way KVIs are defined or measured varies depending on which work package produced them and at what stage they were introduced. This lack of alignment makes cross-initiative comparison difficult and obscures how technical components contribute to societal outcomes across the SNS.

In this context, the KVI ontology is positioned as a common reference model that helps deal with fragmentation, enables comparability across projects, and supports transparency for policymakers, industry actors, researchers, and standardisation bodies that can use it. It addresses these issues by presenting a structure that offers traceability from abstract societal values to concrete indicators, use cases, enablers, and measurable system properties. It delivers cross-cutting value by making value interpretations explicit, resolving conceptual ambiguity, and facilitating consistent reporting of KVIs through a unified set of classes and relationships. By harmonising diverse bodies of both technical and value-oriented knowledge, it attempts a resolution of vocabulary inconsistencies and establishes a standardised reference model for value-based assessment.

The KVI Ontology introduces several innovations that go beyond traditional technology or KPI-oriented models used in mobile network research. First, it is the first ontology to attempt the integration of societal, environmental, and economic values with technical 6G capabilities and enablers in a fully traceable structure, addressing the need for a holistic socio-technical framework. Unlike prior approaches, it enables semantic links between abstract values, concrete indicators, and relevant technologies. This creates a new class of “value-aware” technical assessment that has not been available in previous SNS phases or in standardisation contexts.

Finally, it sets the foundation for future standards activities offering a modular structure that can evolve alongside 6G developments while remaining backward-compatible with existing SNS JU outputs. Its design supports multiple types of users (policy, technical, socio-economic), multiple entry points, and scenario-based queries, enabling richer analyses than traditional KPI-centric frameworks. In this sense, the ontology acts as a novel socio-technical “map” of 6G, connecting values to technology development in a way that is both operationally useful and future-proof.

4.1.2 Engineering Methodology

The development of the KVI Ontology followed the NeOn Methodology, a widely adopted framework for engineering networked ontologies [2]. NeOn was selected for this project because it explicitly supports iterative, collaborative, and reuse-oriented ontology development, aligning with the requirements defined in the ORSD. NeOn accommodates the complexity of SNS projects, where values, indicators, use cases, and technological enablers originate from multiple external documents, standards, and project-specific interpretations, by enabling the construction of interconnected ontology modules rather than a single structure.

We implement NeOn in a streamlined way, focusing on scenario-based development. Specifically, the ontology follows NeOn’s Scenario 2 (“Reusing and re-engineering non-ontological resources”). This scenario was selected because the knowledge landscape surrounding values, KVIs, use cases, verticals, and enablers in SNS JU projects is largely heterogeneous, provided in forms such as tables, spreadsheets, deliverables, white papers, technical frameworks, and domain-specific taxonomies and required harmonization of their vocabularies and hierarchies into a unified semantic model. The scenario-based approach allowed the ontology to evolve in parallel with project findings while ensuring that each iteration remained anchored in the formal requirements we had previously set.

More specifically, reusing Non-Ontological Resources (NORs) refers to the systematic identification and selection of external knowledge sources that can be integrated into the ontology. the process involves assessing whether external resources meet criteria such as domain relevance, conceptual clarity, completeness, granularity, and stability. For the KVI ontology, this meant surveying SNS JU deliverables, results, sustainability frameworks, and project KVI tables to determine which vocabularies and classifications could meaningfully inform the ontology. Each resource was evaluated against ORSD-defined needs. Only resources with sufficient coverage and conceptual consensus across projects were selected.

Re-engineering Non-Ontological Resources refers to the transformation of selected NORs into properly structured ontology components. It involves three core steps:

1 **NOR Reverse engineering:** This step identifies the implicit conceptual model underlying the original resource. For example:
   - Project KVI tables were reverse-engineered to extract concepts like "Value", "Impact", "Objective", "KVI", and "Assessment Style".
   - Technical documents were analysed to identify categories such as "Technological Capability", "Enabler", and "Technical Scenario".
   - Sustainability frameworks were deconstructed into features, practices, SDGs, and aspects.
   - Hierarchical patterns and relationships were extracted

2 **NOR Transformation:** The extracted model was translated into formal OWL 2 constructs. Examples include:
   - Converting SNS JU value lists into a structured hierarchy grouped under sustainability pillars.
   - Transforming enabler taxonomies into the relevant class with subcategories and TRL annotations.
   - Turning sustainability logics into relevant classes.

3 **Ontology Forward engineering:** The structured conceptual model was implemented as an OWL ontology using Protégé, with logical axioms, domain and range definitions, and separation of the modules in 6 interconnected layers:
   - Foundational value concepts (Key Values, etc) layer
   - Indicator concepts layer
   - Stakeholder concept layer
   - Operational layer (Use Cases and Verticals)
   - Technological foundations layer
   - Sustainability and Governance layer

The 6G4Society ontology is implemented using the **OWL 2 Web Ontology Language**, a W3C-standardised formal language designed for expressing complex knowledge on the Semantic Web. OWL 2 offers enhanced modelling capabilities, such as richer datatype support, advanced property expressions and more precise cardinality constraints. An ontology implemented in OWL 2 is composed of classes, properties, individuals, and literal data values, all represented in a machine-interpretable format. Because this language is fully compatible with RDF and commonly exchanged as RDF-based documents, it integrates naturally with existing Semantic Web infrastructures and ensures interoperability with other data sources and ontologies.

Protégé was selected as the environment for developing the KVI Ontology due to its maturity, flexibility, and broad acceptance within the ontology engineering community. It provides intuitive tools for constructing, visualising, and maintaining ontologies expressed in OWL, RDF, and other Semantic Web standards. Its support for modular design and complex class/property structures makes it well suited for capturing the multi-layered relationships inherent in the 6G value ecosystem.

In addition to its modelling capabilities, Protégé integrates state-of-the-art reasoning engines such as HermiT and FaCT++, that enable automated checks for logical consistency, detection of modelling errors, and inference of new knowledge. These features ensured that the evolving ontology remained coherent as new entities were incorporated.

4.1.2.1 Ontological Components

Gruber [3] suggested that ontologies can be modelled using a combination of frame-based structures and first-order logic. In his formulation, an ontology is composed of five essential building blocks: classes, relations, functions, formal axioms and instances.

- **Classes** define the fundamental categories or types of things represented in the ontology. They provide the abstract groupings (e.g., Key Value, Enabler, Use Case) under which individual instances are organised.
- **Relations** specify how classes or instances are connected to one another. They express semantic links that enable the ontology to model structured relationships.
- **Functions** are specialised relations that map an entity to a single output value. They can be seen as mappings where each input has exactly one corresponding result, allowing the ontology to represent deterministic associations.
- **Formal axioms** provide the logical constraints and rules that govern the ontology. They define subclass hierarchies, domains and ranges, disjointness, cardinality, and other logical conditions that ensure semantic consistency and support automated reasoning.
- **Instances (or individuals)** are the concrete manifestations of the ontology's concepts. They represent real or specific elements, such as a particular KVI, a specific Key Value like Trust, or an identified Enabler, populating the class structures with actual data.

Among these, relations are implemented in OWL through two specialised types of properties: object properties and data properties. These properties specify how entities connect to each other or how they are described through concrete attributes, thereby operationalising the relational and functional aspects of the ontology.

An **object property** in an ontology is a type of relationship that links one class or individual to another class or individual. Whereas classes define what things are, object properties describe how things are connected. They express meaningful relations enabling the ontology to model a structured network of interconnected concepts. By formally defining these relationships, object properties allow reasoning engines to infer new knowledge, maintain semantic consistency, and represent complex domain logic in a machine-interpretable way.

A **data property** on the other hand, is an attribute that links a class or individual to a literal value such as a number, string, date, or boolean. Data properties describe *characteristics* or *features* of those entities, like numerical values (e.g., "impactSeverity = 4"), textual descriptions (e.g., "label = 'Safety'"), or other measurable attributes. Data properties allow an ontology to encode concrete, quantifiable, or descriptive information about concepts, enabling more detailed analyses, comparisons, and reasoning over specific values associated with individuals within the ontology.

These components operate under the constraints of formal axioms, which ensure logical consistency by defining rules such as subclass relations, domain and range restrictions, or cardinality constraints. Taken together these elements provide the expressive structure that allows the KVI Ontology to represent complex knowledge in a consistent, machine-interpretable way.

4.1.3 Ontology Specifications

In this sub-section the specifications of the new created ontology are described. The main classes of the aforementioned ontology are presented. Moreover, the basic object and data properties are collectively presented.

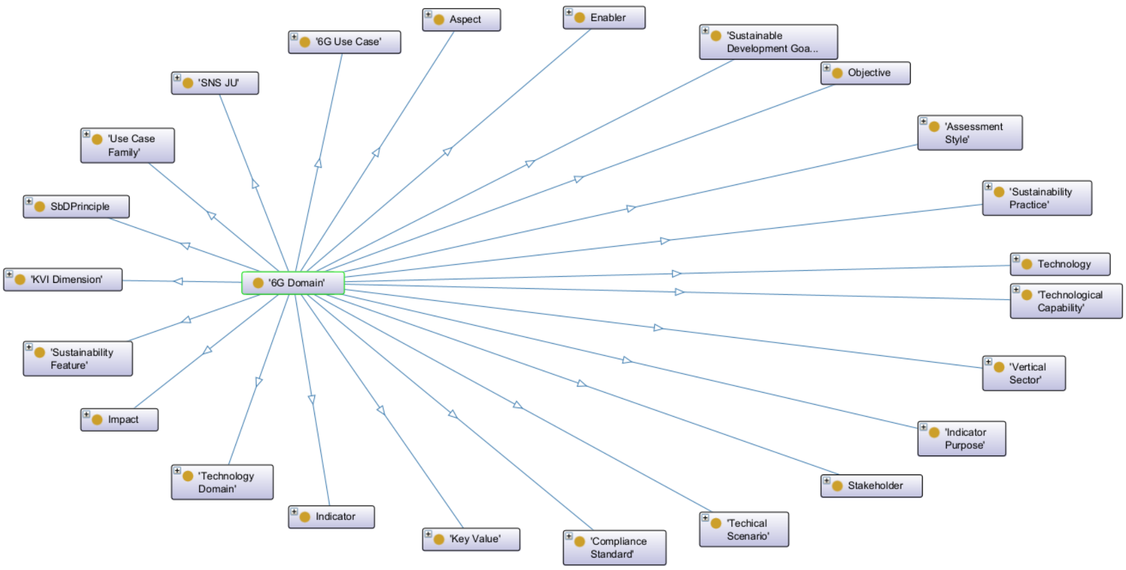

FIGURE 1: 6G4SOCIETY'S 6G KVI ONTOLOGY'S CLASS OVERVIEW

For each class we define:

- Class name: the name of the class which is described
- Definition: the definition and description for this class
- Design Choice: A short justification of the modelling of the class in the context of the 6G value ecosystem and its merit in the value chain created
- Class hierarchy: we provide a graph with the sub-classes (if any exist) of mentioned class
- Object properties: we provide a table with main object properties of the class (if present)
- Data properties: we provide a table with main data properties of the class (if present)

4.1.3.1 Foundational Concepts

***Key Value* class**

The “Key Value (KV)” class and its subclasses, depicted in Figure 2, represent a foundational pillar of the 6G4Society KVI Ontology, as they embody the highest level of abstraction within the ontology’s conceptual hierarchy. Key Values function as “high-level goals” that link all subsequent KVIs to recognized societal, environmental, and economic priorities, thereby ensuring that the ontology remains grounded in sustainability dimensions and shared human values. The KV class defines the normative rationale for value-based assessment by capturing aspirations such as digital inclusion, environmental sustainability, trust, economic resilience, and other values identified in European research initiatives. Within the ontology, the KV class serves as the central semantic anchor from which all indicators, enablers and evidence levels derive meaning, forming the backbone of the ontology’s interpretive logic and its alignment with European values.

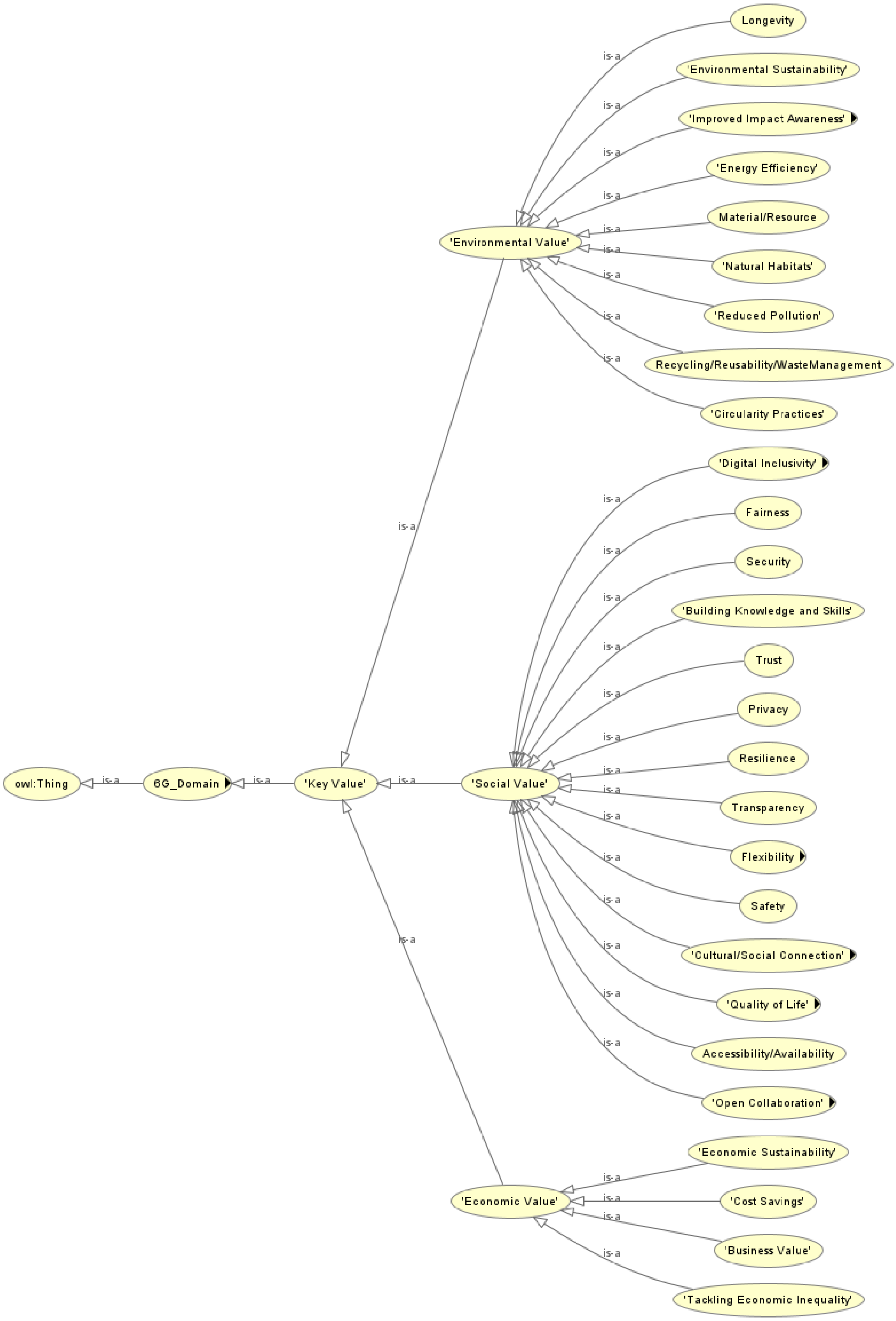

FIGURE 2: "KEY VALUE" CLASS AND SUBCLASSES

The ontology organizes Key Values into the three sustainability pillars: Societal, Environmental, and Economic. This structure is fully compatible with 6G-IA priorities [4], as well as with the SNS JU KVIS White Paper [5], even though the latter adopts a more detailed set of twelve values. Their taxonomy is a pragmatic consolidation of multiple frameworks used across SNS projects and is not intended as a universal or definitive classification. This initial classification ensures conceptual clarity and interoperability across projects and standards, reflecting convergence within the 6G research landscape. As KVIs measure change in terms of economic, social, and environmental outcomes, these pillars delineate the domains where societally meaningful impact is anticipated.

The object properties associated with the Key Value class (Table 5) define how a Key Value relates to other core entities, such as the Key Value Indicators that operationalise it, the stakeholders affected by it, and the technological enablers or use cases through which it can be realised. These specify its semantic position within the broader value-flow architecture. This relational design supports traceability from values to evidence and ensures that sustainability-driven goals can be systematically propagated through the modelling of KVIs, enablers, KPIs, and stakeholder responsibilities.

This design directly reflects and fulfills the mandate defined in the Ontology Requirements Specification Document (ORSD), detailed in D4.3 deliverable of 6G4Society [1], which specified that the ontology must provide a standardized, semantically rich framework for representing societal, environmental, and economic principles and linking them to their indicators, stakeholders, and technological/operational contexts.

TABLE 5: OBJECT PROPERTIES OF "KEY VALUE" CLASS

Object Property	**Description**	**Range**
isOperationalisedByObjective	Relates a Value to the Objectives that make it concrete and actionable.	Objective
isRelevantForStakeholder	Relates a Key Value to the stakeholder groups for whom this value is significant, impacted, or considered a priority.	Stakeholder
isIndicatedByKVI	Links a Key Value to the Key Value Indicators that measure, express, or provide evidence of its achievement.	Key Value Indicator (KVI)
isTargetedByProject	Relates a Key Value to the projects that target or contribute to it.	Project
isAdressedByUseCase	Relates a Key Value to the 6G Use Cases that operationalise or instantiate actions intended to address	6G Use Case

	that value in practice.	

***Objective* class**

FIGURE 3: "OBJECTIVE" CLASS

The “Objective” class, Figure 3, represents the intermediate layer that translates high-level Key Values into concrete, actionable directions for interpretation, assessment, and design. An objective represents a goal, desired outcome, or actionable direction that operationalizes a Key Value (KV) by expressing what specifically should be achieved to support that value. Each Key Value is broken down into a set of specific, value-based objectives (e.g., ensuring equal access, promoting digital literacy, cultural sensitivity, preventing harm, enabling safety, and supporting vulnerable groups). This class encapsulates these intentions as formal semantic entities. It is positioned directly after the Key Value class in the value hierarchy and serves as the operational bridge between abstract societal values and the KVIs that later quantify or qualify progress. Their utility lies in clarifying *what it means* to pursue a given value in practice, unpacking, for example, how “Inclusivity” or “Safety” materialises into domain-specific aims that stakeholders can act on. It structures the pathway from values to indicators. The next table (Table 6) contains the basic object properties of “Objective” class.

TABLE 6: OBJECT PROPERTIES OF "OBJECTIVE" CLASS

Object Property	**Description**	**Range**
isOperationalisedByPractice	Relates a high-level Objective to the Sustainability Practices that make it materialise it.	Sustainability Practice
operationalisesValue	Relates an Objective to the Value it operationalises or makes concrete.	Key Value

TABLE 7: DATA PROPERTIES OF "OBJECTIVE" CLASS

Data Property	**Description**	**Range**
objectivePriority	Priority level of an objective in the context of a Key Value, where 1 = essential objective, 2 = important supporting objective, and 3 = optional or context-specific	Integer: 1-3

	objective.	

Impact class

The "Impact" class and its subclasses (Figure 4) represent an actual change in the conditions, opportunities, or wellbeing of one or more stakeholders that arises, at least in part, from the design, deployment, or use of 6G technologies in relation to a Key Value. It is further split into positive and negative impact, meaning an impact that is beneficial for at least one stakeholder group or an Impact that is harmful or creates new risks for at least one stakeholder group, respectively.

This class formalises the real-world effects associated with achieving a given Objective, capturing the broader consequences that extend beyond the immediate outputs of a technology. Clear distinctions need to be made between (1) Outputs, which are the technical artefacts produced by a project, (2) Outcomes, the ways stakeholders adopt or interact with those artefacts, and (3) Impacts, the higher-level changes these behaviours generate within communities, institutions, ecosystems, or markets. The Impact class corresponds directly to this third layer. It represents effects such as improved social cohesion, enhanced public safety, reduced inequalities, economic resilience, or environmental harm reduction. This separation is critical, since it ensures that the ontology does not conflate goals with results, but instead models the full value pathway from principle → goal → measurement → real-world change.

This classes object and data properties are given in Table 8 and Table 9 respectively. The data properties provide an attempt at quantifying the likelihood and the severity of a certain impact and are projected to allow reasoning engines, designers, and policymakers to compare impacts, assess trade-offs, and determine where mitigation or amplification efforts are most needed. While little to no empirical data currently exist to populate these properties with precise, evidence-based values, the ontology includes them to establish a conceptual and methodological scaffolding for future assessment.

This design as a semantic and methodological foundation is true, but the ontology is not left unpopulated. In the context of 6G4Society, the ontology has been populated with the impact chains of five exemplar values, selected to reflect core societal priorities for 6G. For each of these values, relevant indicators, stakeholder perspectives, operational contexts, and technological implications have been instantiated, as well as objectives and impact scopes based on stakeholder feedback. This work was carried out in close conjunction with WP3 activities, drawing on project surveys and qualitative analyses, and has undergone rounds of external validation with domain experts throughout the project lifecycle. As such, the ontology already demonstrates practical utility as a structuring tool, while remaining intentionally extensible to accommodate additional input and empirical evidence from future projects.

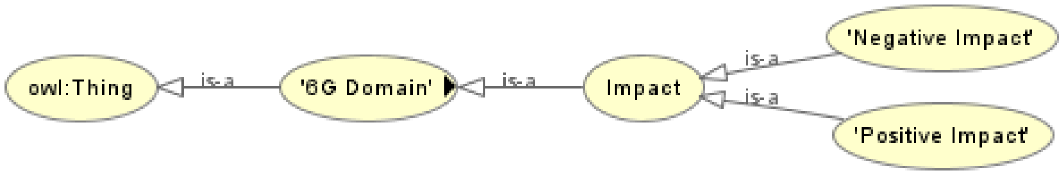

FIGURE 4: "IMPACT" CLASS AND SUBCLASSES

TABLE 8: OBJECT PROPERTIES OF "IMPACT" CLASS

Object Property	**Description**	**Range**
resultsFromValue	The impact occurs because this value is pursued, achieved, neglected, or challenged.	Key Value
experiencedBy	Connects an Impact to the stakeholder group(s) who experience that change in practice.	Stakeholder
benefits	Indicates that a Positive Impact produces a beneficial effect for a stakeholder group.	Stakeholder
harms	Indicates that a NegativeImpact produces or increases harm or risk for a stakeholder group.	Stakeholder

TABLE 9: DATA PROPERTIES OF "IMPACT" CLASS

Data Property	**Description**	**Range**
impactLikelihood	Probability that the impact occurs in practice.	High, Low, Medium
impactSeverity	Indicates the intensity of the impact for affected stakeholders.	Integer: 1-5

4.1.3.2 Indicator Concepts

This subchapter introduces the core conceptual elements that make up the Indicator layer of the ontology, which operationalises the transition from abstract values and objectives to measurable evidence. The classes presented here and their associated data and object properties define how progress toward a Key Value can be assessed, monitored, and interpreted in a structured, transparent way. The Indicator classes address how we measure change. By modelling Indicators as formal ontology entities and linking them to Values, Objectives and Impacts, this chapter establishes the methodological foundation for reporting

KVIs and KSIs as outlined in the wider framework. Collectively, these classes provide the groundwork needed for consistent value assessment across projects, supporting traceability and comparability in an evolving environment.

***Indicator* class**

The "Indicator" class and its subclasses (Figure 5) represents the measurable elements used to assess whether progress is being made toward a given value, performance or sustainability

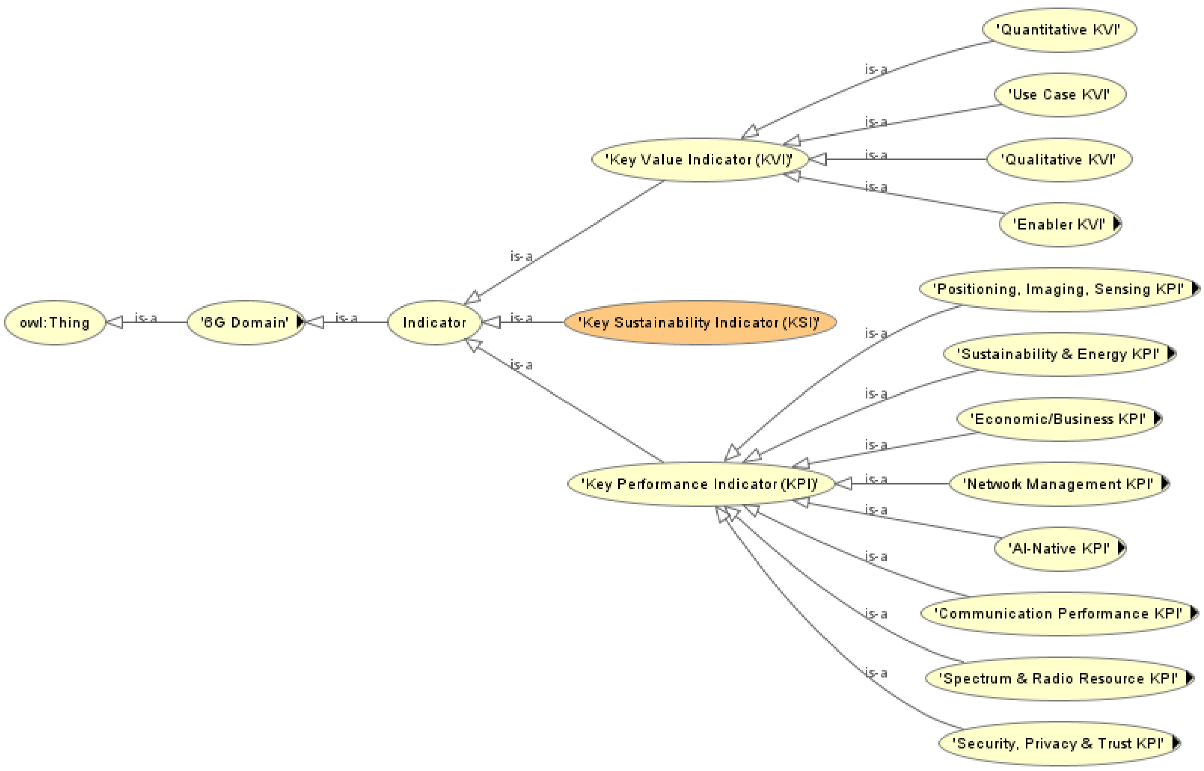

FIGURE 5: "INDICATOR" CLASS AND SUBCLASSES

objective. This class ensures a rigorous and transparent connection between values, goals, and measurable outputs, forming the operational backbone of the value-assessment process. Object properties of the parent indicator class are given in Table 10.

TABLE 10: OBJECT PROPERTIES OF "INDICATOR" CLASS

Object Property	**Description**	**Range**
assessedByStyle	Relates an Indicator to the Impact Assessment style(s) used to evaluate or interpret it.	AssessementStyle

***Key Value Indicator (KVI)* class**

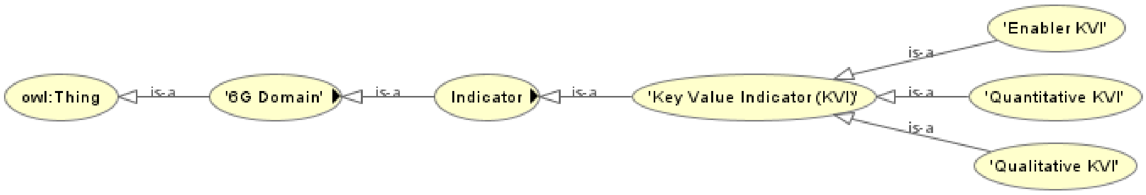

FIGURE 6: "KEY VALUE INDICATOR (KVI)" CLASS AND SUBCLASSES

The "Key Value Indicator (KVI)" class and its subclasses (Figure 6) represent the indicators explicitly anchored to the value hierarchy and specifically designed to measure progress toward achieving a Key Value through the Objectives attributed to it in the ontology. KVIs shift the evaluation focus from technical performance ("can the system work?") to value creation ("how does the system change conditions for stakeholders?"). Within the ontology, the KVI class formalises these indicators as structured, semantically linked entities that capture evidence of stakeholder-experienced outcomes and early signals of broader societal, environmental, or economic impacts. This class also accommodates the diversity of assessment methods, quantitative and qualitative, highlighted in the KVI framework, enabling a rich representation of how change is observed or inferred [5], [6]. An Enabler KVI subcategory is included to capture indicators that assess whether the essential technical, organisational, or social ingredients needed to achieve a value are in place, without measuring impact directly. These KVIs act as strategic proxies, especially in early research stages, by evaluating the presence and effectiveness of enablers that make value-related outcomes possible. The object and data properties linking these entities to the rest of the semantic structure are given in Table 11and Table 12 respectively.

TABLE 11: OBJECT PROPERTIES OF "KEY VALUE INDICATOR (KVI)" CLASS

Object Property	**Description**	**Range**
constrainsKPIRequirement	*A value expectation establishes thresholds or conditions for relevant KPIs.*	KPI
evaluatedByUseCase	Relates a Key Value Indicator to the 6G Use Cases in which it is assessed.	6G Use Case
hasDimension	Indicates which dimension(s) of value a Key Value Indicator represents.	KVI Dimension
hasIndicatorPurpose	A relation connecting a Key Value Indicator (KVI) to the underlying purpose that motivates the indicator and provides semantic meaning for interpreting the KVI.	Indicator Purpose

hasSupportingKPI	Associates a KVI with one or more KPIs that operationalise the performance needed to realise the value it measures.	KPI
existingKPIAlignment	Links an Enabler KVI to an established KPI from existing 5G/6G frameworks, indicating how current performance indicators already contribute to measuring this KVI.	KPI
newKPIAlignment	Relates a KVI to a newly defined or emerging KPI to measure aspects not captured by legacy KPIs. This property identifies novel KPIs developed specifically to operationalise this Enabler KVI.	KPI
hasTradeoffWith	Specifies conflicting or constraining relationships between indicators.	KVI, KSI
indicatesValue	Is attributed to a KVI to denote the relationship of specifying, measuring or indicating progress towards its respective Value	Key Value
isEnabledBy	Connects a Key Value Indicator to the technological enablers that make it measurable, feasible, or achievable.	Enabler
assessesEnabler	Links an Enabler KVI to the enabler whose properties, performance, or value contribution it is intended to evaluate.	Enabler
isInterdependentWith	Indicates that the value measured by one KVI affects or is affected by another.	Key Value Indicator

reportedByProject	Links a KVI to the respective project(s) reporting or measuring it.	Project
relatedToSDG	Associates a Key Value Indicator with the Sustainable Development Goals to which it contributes or aligns.	Sustainable Development Goal
isProxyFor	Identifies which deeper societal outcomes the KVI acts as an anticipatory proxy for.	Impact

TABLE 12: DATA PROPERTIES OF "KEY VALUE INDICATOR (KVI)" CLASS

Data Property	**Description**	**Range**
hasUnitOfMeasurement	Specifies the unit used to quantify the quantitative KVI	string

***Key Performance Indicator (KPI)* class**

The “Key Performance Indicator (KPI)” class and its subclasses (Figure 7) group traditional performance-oriented indicators into a coherent taxonomy derived from multiple authoritative 6G sources and sustainability frameworks. Because no unified or comprehensive KPI categorisation exists across standards bodies, the ontology adopts a synthesis of the most widely referenced categories and structures, identified across the ITU IMT-2030 framework [7], the 6G Trials and Validation white paper [8], the NGMN Green Future Networks KPI report [9], the comparative analysis of 6G use-case frameworks [10], the Hexa-X D1.1 vision deliverable [6] and 5G-PPP indicators for the previous 5G generation [11]. Each source contributes a distinct set of KPI clusters spanning performance, radio/spectrum, sensing, management, sustainability, security, and AI-native, that together form the taxonomy implemented in the ontology to ensure completeness and interoperability. Each category is valid within its originating domain and integrating them allows the ontology to bridge technical performance evaluation (KPIs) with value-based assessment (KVIs), making explicit how technical enablers support or constrain the realisation of societal, environmental, and economic objectives. The class’s object and data properties are given in Table 13 and Table 14 respectively.

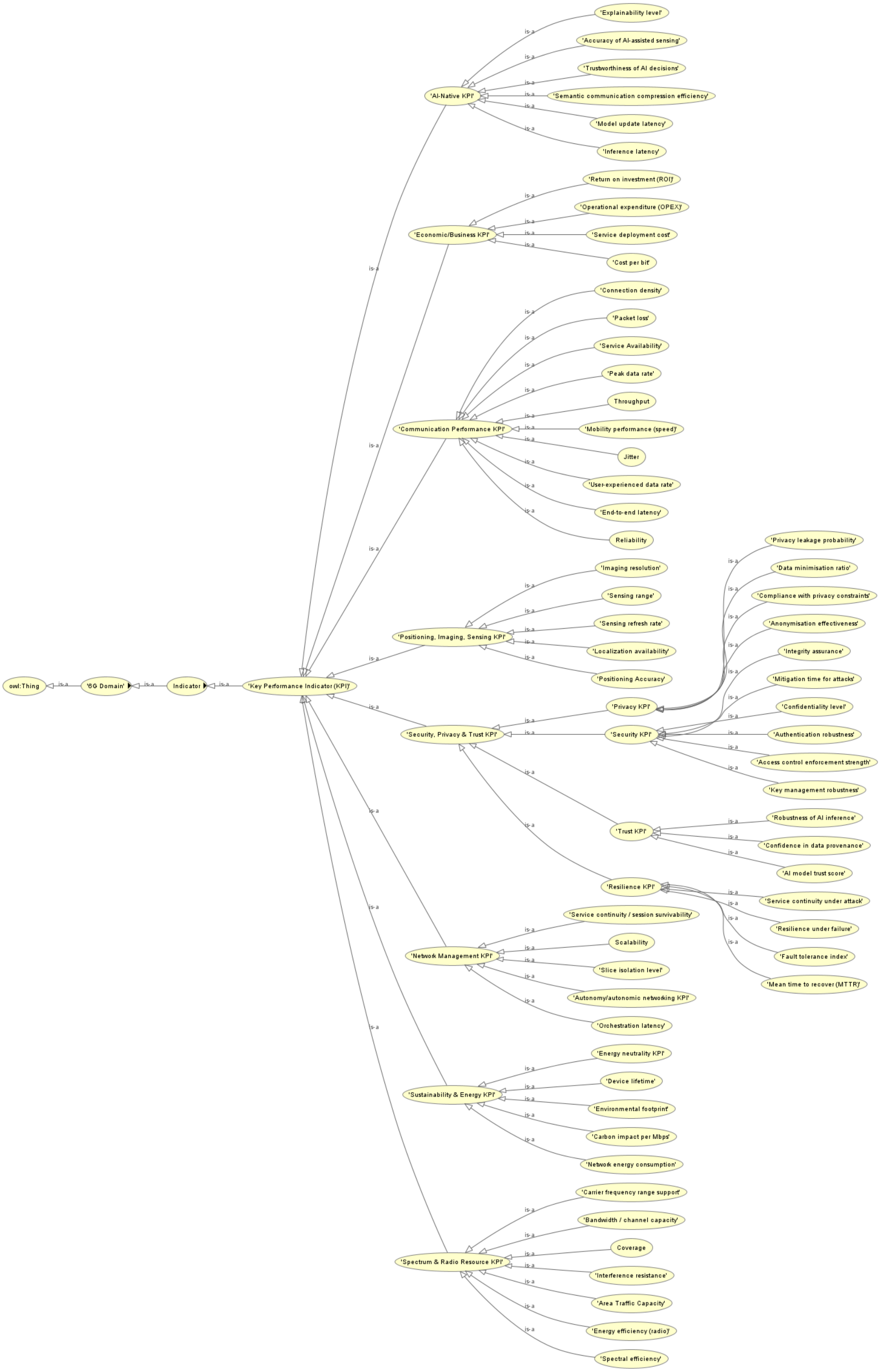

FIGURE 7: "KEY PERFORMANCE INDICATOR (KPI)" CLASS AND SUBCLASSES

TABLE 13: OBJECT PROPERTIES OF "KPI" CLASS

Object Property	**Description**	**Range**
supportsValueRealisation	A relation indicating that a KPI provides measurable performance evidence required to enable or contribute to the value expressed by a KVI.	Key Value Indicator

TABLE 14: DATA PROPERTIES OF "KPI" CLASS

Data Property	**Description**	**Range**
hasUnitOfMeasurement	Specifies the unit used to quantify the KPI (e.g., milliseconds, Mbit/s, %, Joules)	string
targetsMaxValue	Indicates the maximum threshold or upper performance target associated with the KPI.	float
targetsMinValue	Indicates the minimum threshold or lower performance target associated with the KPI.	float

Key Sustainability Indicator (KSI) **class**

The “Key Sustainability Indicator (KSI)” class represents a special category of indicators used to evaluate whether the values, impacts, and benefits associated with a technology, use case, or socio-technical configuration contribute to long-term sustainability [12]. Unlike value indicators that describe present or immediate effects, KSIs assess the durability, systemic interdependencies, equity, and diffusion of impacts across time, stakeholders, and ecological and social boundaries. A KSI signals whether a value trajectory leads toward or away from sustainable futures. In essence they represent KVIs configured for sustainability. A KSI signals whether a value trajectory leads toward or away from sustainable futures. Because the KSI concept and its methodological framework are still evolving, the current ontology defines the KSI taxonomy at class level only, without instantiating concrete individuals, thereby providing a stable conceptual scaffold that future projects can refine and populate as evidence and practice mature. Its object properties that distinguish it and position it clearly in the 6G value ecosystem are reported in Table 15.

TABLE 15: OBJECT PROPERTIES OF "KSI" CLASS

Object Property	Description	Range
hasSustainabilityFeature	Links a Key Sustainability Indicator to the Sustainability Feature(s) it incorporates. A KSI must have at least one Sustainability Feature.	Sustainability Feature
isSustainabilityConfigurationOf	A relation indicating that a Key Sustainability Indicator is the sustainability-oriented configuration of another indicator, allowing a KVI to be extended with sustainability properties such as alignment, durability, diffusion, equity, and interdependence.	Key Value Indicator
hasTradeoffWith	Specifies conflicting or constraining relationships between indicators.	KVI, KSI

***KVI Dimension* class**

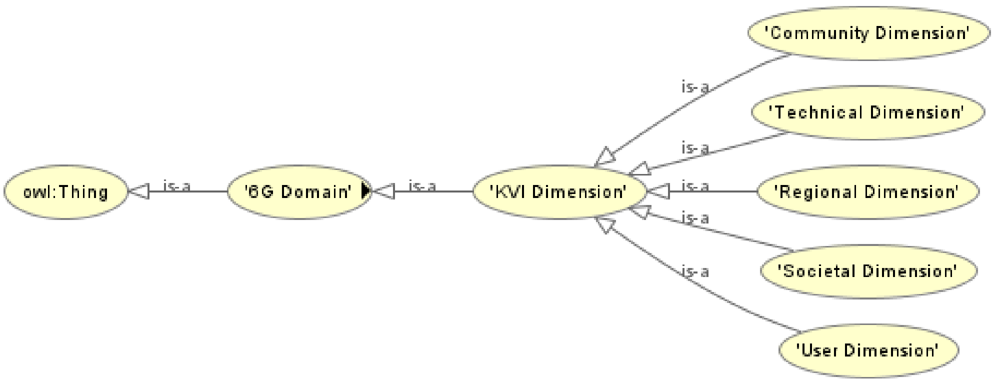

FIGURE 8: "KVI DIMENSION" CLASS AND SUBCLASSES

The "KVI Dimension" class and its subclasses, as depicted in Figure 8, capture the different layers through which value can manifest and be assessed, structuring KVIs according to the scale, scope, and depth of the change they observe. Each dimension corresponds to a distinct sphere of impact. It defines the conceptual "scale" of the value described by the KVI. Robust indicators must distinguish between first-order effects related to technological capabilities and higher-order effects such as behavioural change, community benefit, system-level readiness, and long-term societal transformation. This class essentially provides meta-properties of an indicator, specifying where the indicator expresses value, but does not inform of the purpose of the indicator itself.

These layers form a coherent set of “value dimensions” that help translate abstract values into measurable, actionable evidence. By modelling these as ontology classes, the “KVI Dimension” class provides a semantic layer that ensures each KVI is positioned within the appropriate evaluative lens and aligned with the decision-making needs associated with that layer. This avoids conflating outputs, outcomes, and impacts. The result is a structured way to encode the multi-dimensional nature of value creation, enabling KVIs to reflect not only what changes but how value propagates across technical, social, and institutional systems.

Assessment Style **class**

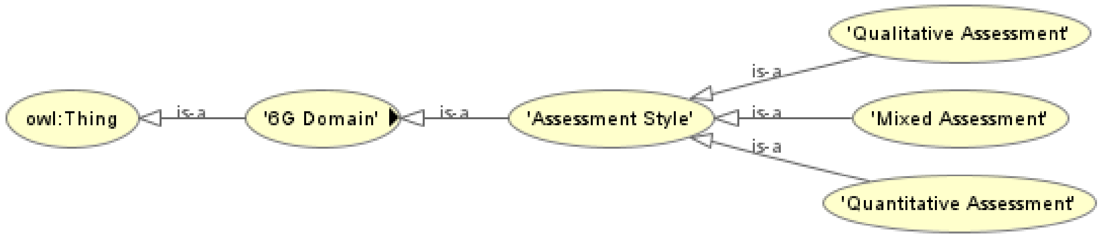

FIGURE 9: “ASSESSMENT STYLE” CLASS AND SUBCLASSES

The “Assessment Style” class and its subclasses (Figure 9) defines the methodological approach used to evaluate an Indicator, clarifying how evidence is generated and interpreted. Because KVIs can rely on diverse forms of proof, ranging from quantitative measurement to qualitative stakeholder insights or mixed-method proxy analysis, this class ensures that each indicator is explicitly linked to the type of evaluative logic it requires. This is especially important in low-TRL and early-stage 6G research, where direct real-world outcomes are not yet observable and KVIs often rely on strategic proxies, qualitative assessments, or anticipatory methods. The inclusion of this layer adds transparency to how indicators are constructed, supports consistency across projects, and helps match each KVI to the most appropriate data sources and decision-making context. Its main object property is given in Table 16.

TABLE 16: OBJECT PROPERTIES OF "ASSESSEMENT STYLE" CLASS

Object Property	**Description**	**Range**
assessesIndicator	Links an assessment style to the indicator that it is used to evaluate.	Indicator

Indicator Purpose **class**

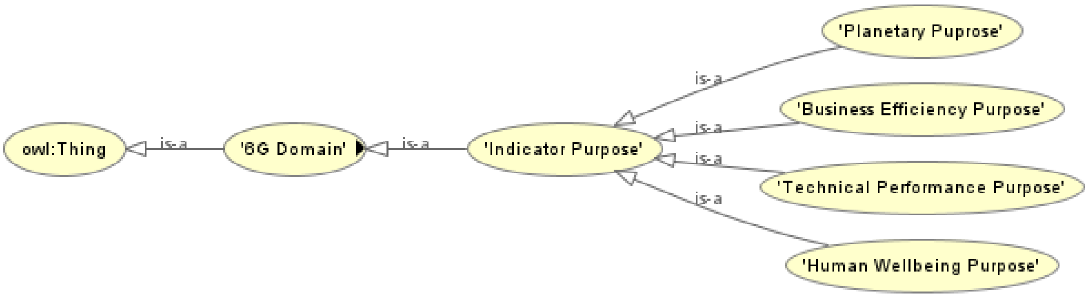

FIGURE 10: "INDICATOR PURPOSE" CLASS AND SUBCLASSES

The "Indicator Purpose" class and its subclasses (Figure 10) specify why a particular indicator is being measured and what type of decision or evaluative need it serves. Indicators must be purpose-driven, since different stages of research and different stakeholder needs require distinct forms of evidence, such as tracking progress during development, informing design adaptations, evaluating outcomes for accountability, or establishing baselines for long-term monitoring.

***Sustainability Feature* class**

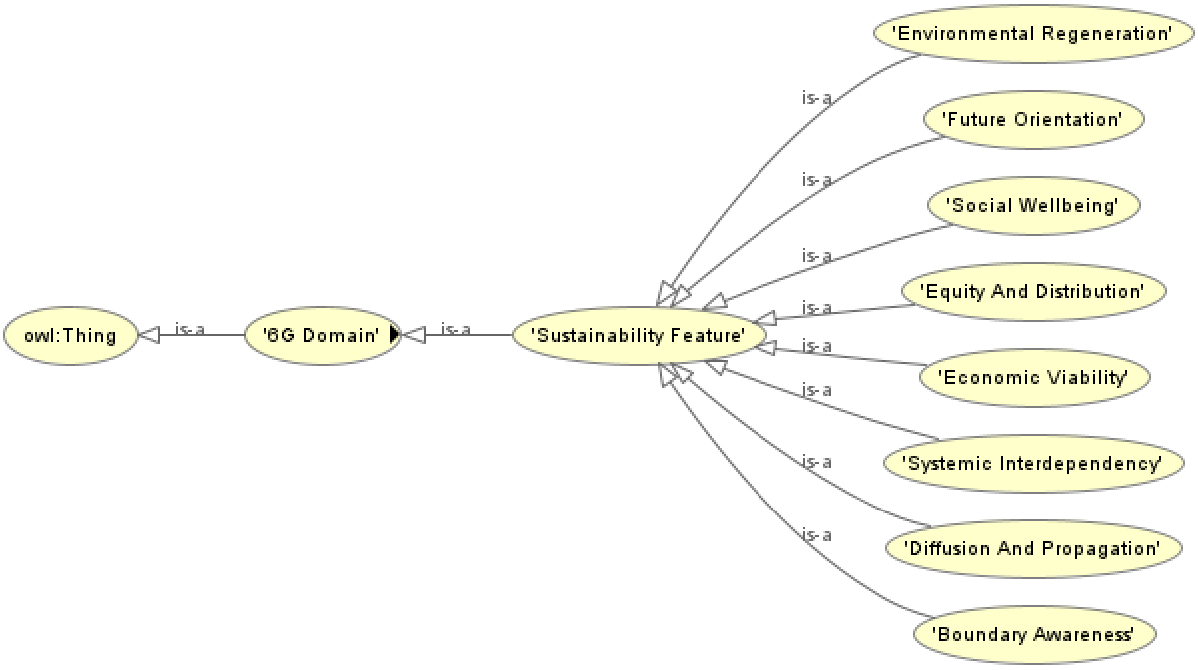

FIGURE 11: "SUSTAINABILITY FEATURE" CLASS AND SUBCLASSES

The "Sustainability Feature" class (Figure 11) is a conceptual characteristic that must be applied to a Key Value Indicator to interpret its evolution, systemic interactions, fairness, and alignment with ecological and societal boundaries. Sustainability Features are the conditions that allow a KVI to be transformed into a Key Sustainability Indicator (KSI). Sustainability Features describe the additional dimensions, such as temporal orientation, systemic interdependencies, distributional fairness, durability, and boundary awareness that distinguish a Key Sustainability Indicator (KSI) from a KVI. These features articulate the criteria needed to evaluate whether impacts contribute to long-term, equitable, and resilient socio-technical futures. This design choice allows the ontology to remain flexible as sustainability methodologies and sustainability indicator frameworks evolve, while maintaining a clear semantic connection between high-level sustainability concepts and the concrete evaluative elements they inform.

4.1.3.3 Stakeholder Concepts

***Stakeholder* class**

The “Stakeholder” class and its subclasses, depicted in Figure 12, represents the individuals, groups, organisations, and public institutions whose experiences, needs, risks, and benefits shape and are shaped by 6G technologies. Across ecosystem value mappings performed in 6G4Society, stakeholders consistently emerge as central to defining what is at stake in each Key Value investigated. The KVI framework reinforces this by emphasising that meaningful indicators must measure changes experienced by stakeholders, not just technical outputs or user-level interactions.

Within the ontology, the Stakeholder class therefore provides the anchor point for linking values, objectives, impacts, and indicators to the real-world actors they affect. It supports the explicit modelling of whose needs must be considered, whose perspectives inform value definitions, and who uses KVI results to make decisions. These diverse roles and dependencies, position this class as pivotal in ensuring that value assessments remain grounded in the multi-actor nature of socio-technical systems. The main functions this class performs are given in Table 17 and Table 18. A note should be made that although consistent empirical data for stakeholder prioritization according to each Key Value and its objectives does not yet exist, accumulated domain knowledge and the evolving understanding of stakeholder roles make a relevant property both valid and necessary in the ontology model for guiding future evidence collection and ensuring that indicators reflect real-world relevance.

FIGURE 12: "STAKEHOLDER" CLASS AND SUBCLASSES

TABLE 17: OBJECT PROPERTIES OF "STAKEHOLDER" CLASS

Object Property	Description	Range
engagesWithValue	Indicates that a stakeholder group is significantly affected by, or actively contributes to, the interpretation and realisation of a Key Value.	Key Value

TABLE 18: DATA PROPERTIES OF "STAKEHOLDER" CLASS

Data Property	Description	Range
stakeholderPriorityLabel	Priority label of a stakeholder group in the context of a given Key Value	Primary, Secondary, Peripheral

4.1.3.4 Operational Layer Concepts

This subsection introduces the operational layer of the ontology, which connects high-level values and indicators to the concrete contexts in which 6G technologies are developed, deployed, and evaluated. The classes presented here provide the structural link between abstract value frameworks and the practical situations that shape technological performance and societal outcomes. They define the operational landscape in which values and their respective indicators can be meaningfully interpreted, respecting realistic deployments, sector-specific constraints, and the diversity of 6G application contexts in the value assessment chain.

***6G Use Case* class**

FIGURE 13: "6G USE CASE" CLASS

The "6G Use Case" class, presented in Figure 13, represents the central operational unit of the ontology, giving a concrete instance of activity, service, or interaction where values, indicators, enablers, and technical performance come together in practice. It is not subdivided internally. Instead, it provides a high-level, flexible container into which evidence from projects, trials, or design studies can be mapped. This design choice ensures that every real-world or research-reported use case can be positioned along three orthogonal axes: its thematic grouping (Use Case Family), its network or system requirements (Technical Scenario), and its application domain (Vertical Sector), with properties that relate it to the respective classes, discussed next. This structure reflects the ontology's requirement to support concrete project evidence and map value-oriented indicators to real deployment contexts. By modelling use cases at this high level, the ontology makes its attempt at interoperability across the heterogeneous scenarios discussed in various SNS JU spaces. It allows different projects and verticals to report evidence in a comparable manner, making this class the operational link through which Key Values, KVIs and enablers become traceable and actionable in real socio-technical contexts. Its object properties that create conceptual links to the rest of the ontology entities are given in Table 19.

TABLE 19: OBJECT PROPERTIES OF "6G USE CASE" CLASS

Object Property	Description	Range
contributesToValue	Indicates that a 6G Use Case contributes to the realisation or advancement	Key Value

	of a specific Key Value by providing evidence, outcomes or impacts aligned with that value.	
evaluatesKVI	Relates a Use Case to its relevant KVIs	Qualitative KVI, Quantitative KVI
hasSustainabilityAspect	Is attributed to a sustainability design aspect (Sustainable6G or 6GforSustainability)	Aspect
hasTechnicalScenario	Categorises a 6G Use Case according to the overarching technical demands it places on the network.	Technical Scenario
linkedToKPI	Is explicitly linked to a KPI	Key Performance Indicator (KPI)
hasUseCaseFamily	Links a concrete use case to one or more abstract use case families it belongs to.	Use Case Family
targetsVerticalSector	Links a Use Case to the vertical sector(s) it is primarily intended to target or serve.	Vertical Sector
isAppliedInSector	Indicates that a Use Case is actually applied, trialed, or deployed in a specific vertical sector (not just conceptually targeting it)	Vertical Sector
isUseCaseOf	Relates a 6G Use Case to the project(s) in which it is developed or demonstrated.	Project
requiresEnabler	Identifies the technological enablers that are necessary for implementing, deploying, or supporting the operation of a 6G Use Case.	Enabler

***Technical Scenario* class**

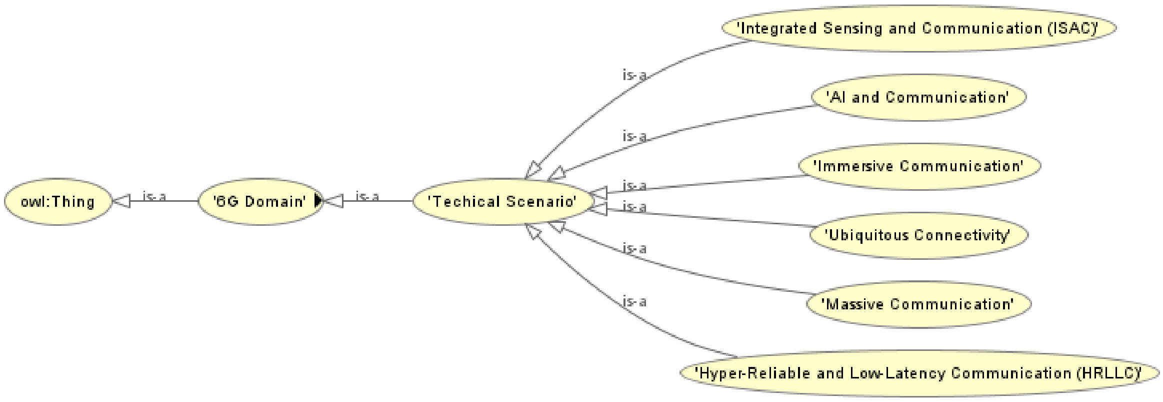

FIGURE 14: "TECHNICAL SCENARIO" CLASS AND SUBCLASSES

The "Technical Scenario" class and its subclasses, presented in Figure 14, represent a high-level category of network usage conditions in IMT-2030 (6G) [13], characterised by a distinct set of service requirements, performance targets, and communication behaviours that the system must support. It does not describe specific applications or technologies but instead is used to group use cases according to the overarching technical demands they place on the network. Technical Scenarios define the "mode of operation" of the network and serve as the canonical capability-based classification framework used by ITU to characterise 6G services.

Technical Scenarios form the first layer of use case categorisation and capture the underlying technical behaviour of a use case. They correspond to cross-cutting technology pillars recognised in major global 6G initiatives and are included because many SNS JU projects develop use cases whose primary purpose is not vertical deployment, but rather the advancement, validation, or experimentation of core technical capabilities. This class is therefore necessary to represent technology-centric use cases that may not align with any particular vertical sector. By providing a dedicated ontological space for these network-focused scenarios, Technical Scenarios enable a clean separation between technical motivations and vertical applications, ensuring that both types of use cases can be classified accurately and compared meaningfully within the ontology.

***Use Case Family* class**

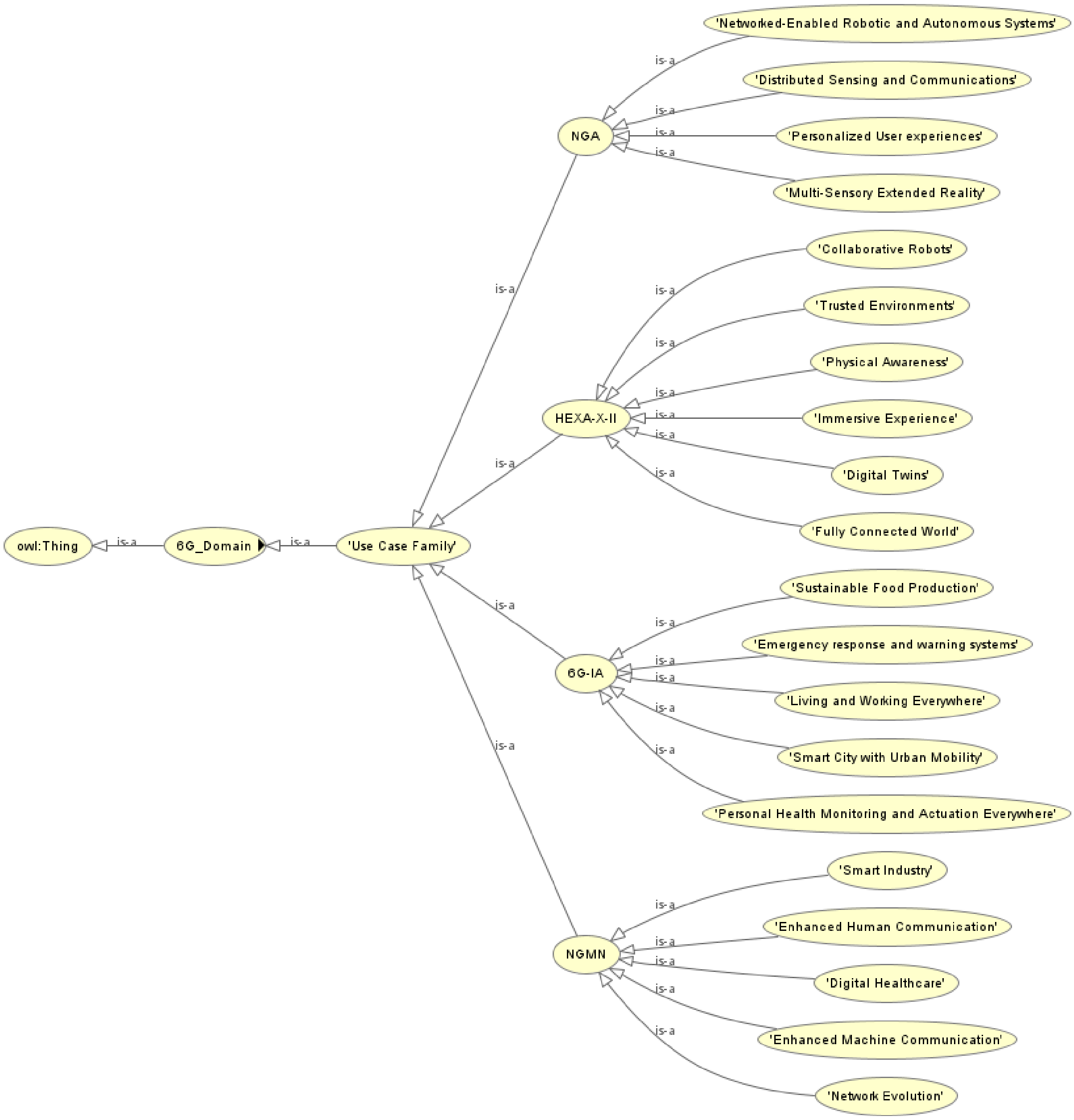

FIGURE 15: "USE CASE FAMILY" CLASS AND SUBCLASSES

The "Use Case Family" class and its subclasses (Figure 15), is an abstract grouping of use cases that share common service characteristics and functional patterns. They reflect how major 6G initiatives, such as Hexa-X-II [6], NGMN [14], 6G-IA [10], [4], or NGA [10] and published studies in Use case importance [15], structure their vision of 6G capabilities and applications. They do not represent industrial sectors but instead capture high-level cross-cutting themes that recur throughout multiple verticals. Within the ontology's use case categorisation, Use Case Families form the second layer of abstraction, offering a functional or interactional context in which individual Use Cases can be understood. Individual Use Case instances may belong to one or more families depending on the functionality they exhibit.

This class is necessary because it enables the ontology to harmonise vocabulary across diverse research initiatives without forcing inconsistent or incompatible concepts into a single rigid taxonomy. Each family functions as a semantic clustering layer that captures conceptual intent while preserving the distinct organisational structures and terminologies used by different projects. In doing so, the ontology supports clearer interpretation, strengthens comparability across initiatives, and helps users trace how high-level research agendas are translated into concrete 6G use cases.

***Vertical Sector* class**

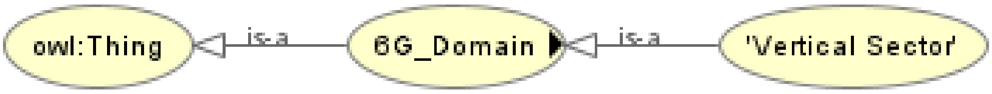

FIGURE 16: "VERTICAL SECTOR" CLASS

The "Vertical Sector" class (Figure 16) represents an industry domain where 6G technology is applied. A Vertical Sector allows the ontology to represent application context in a Use Case, i.e., where a use case is applied or where a project focuses its innovation. Vertical Sectors therefore form the third layer of the Use Case classification, providing the broader domain context in which a use case is applied and interpreted. They enable cross-project integration and comparison of use cases on the basis of shared industry domains. Without them, it would be impossible to answer questions such as "Which projects address agriculture?", "Which use cases in different projects relate to health?", or through ontological inference "WhichKVIs have been reported by SNS JU projects for use cases in the Education vertical sector, and which enablers support their achievement?". They anchor the ontology in real-world deployment contexts and allow mapping of 6G technologies to socioeconomic benefits.

This class's object property is given in Table 20. Table 21 presents a set of theoretical importance indices for Vertical Sectors, expressed through data properties that characterise how critical certain values are within each domain. These indices, while not yet drawing on substantial empirical data, serve, however, as conceptual markers reflecting widely acknowledged priorities in 6G-related verticals [8]. They provide a useful reference point for understanding which value dimensions may require particular attention when analysing or designing 6G use cases within a given sector.

TABLE 20: OBJECT PROPERTIES OF "VERTICAL SECTOR" CLASS

Object Property	**Description**	**Range**
supportedByEnabler	Expresses that a given VerticalSector is supported by a specific Enabler.	Enabler

TABLE 21: DATA PROPERTIES OF "VERTICAL SECTOR" CLASS

Data Property	**Description**	**Range**
ethicsImportanceIndex	How important ethical considerations are for this vertical in 6G context.	High, Low, Nominal

inclusionImportanceIndex	Importance of Inclusion as a key value for this vertical in the 6G context	High, Low, Nominal
privacyImportanceIndex	How critical privacy is in this vertical	High, Low, Nominal
securityImportanceIndex	How critical security is from a value perspective in this vertical	High, Low, Nominal
trustImportanceIndex	Prominence of Trust for this vertical.	High, Low, Nominal

4.1.3.5 Technological Foundation Concepts

The technological foundation concepts of the ontology establish the core structures needed to map how concrete 6G technologies, capabilities, and enabling mechanisms support value creation, indicator measurement, and use-case realisation. This part of the ontology introduces four tightly connected classes which together form the technical backbone linking the value system to the operational 6G ecosystem. Together, they provide the ontology with a structured and interoperable way to represent the technical foundations of 6G research. They allow value-oriented indicators to be traced back to concrete technologies and implementation conditions, fulfilling the set requirements for modularity, traceability, and integration with existing 6G frameworks. This design ensures that the ontology aligns with how the wider SNS ecosystem structures its research and supports evidence generation across projects and use cases.

***Technology Domain* class**

FIGURE 17: "5G DEVICE" CLASS AND SUBCLASSES

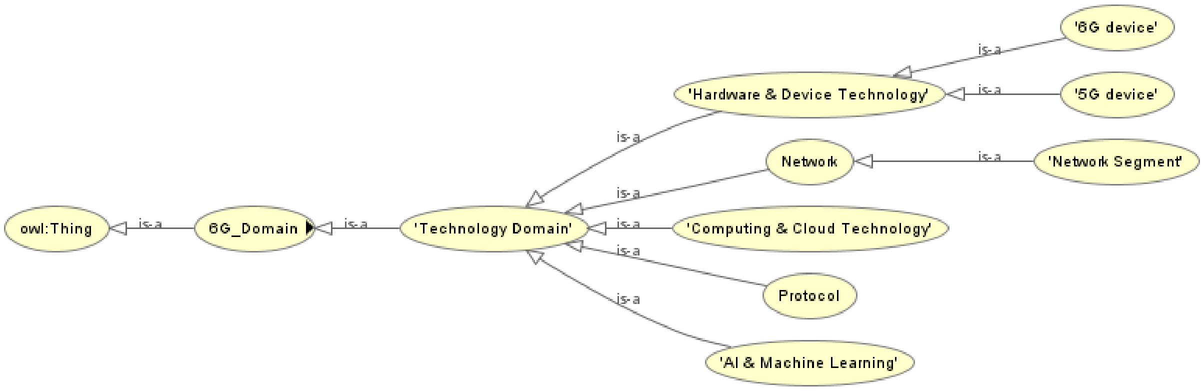

FIGURE 18: TECHNOLOGY DOMAIN" CLASS AND SUBCLASSES

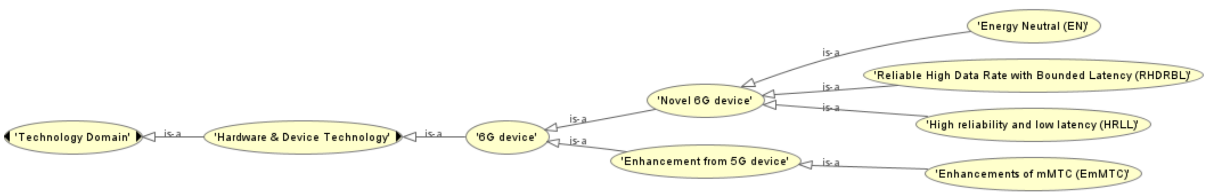

FIGURE 19: "6G DEVICE" CLASS AND SUBCLASSES

The “Technology Domain” class (Figure 17, Figure 18 & Figure 19) represents the most foundational and low-level category in the technological layer. It groups technologies into broad architectural or functional families. These domains reflect how the 6G research community and standardisation bodies typically structure technical landscapes, drawing on widely recognised technical taxonomies. The ontology uses these established conceptual groupings to maintain interoperability with existing technical documentation, and to enable projects familiar with 6G architecture to intuitively locate technologies within familiar conceptual boundaries.

This technical taxonomy is detailed enough to capture individual technical components, while remaining abstract enough to avoid unnecessary complexity. By modelling Technology Domains explicitly, the ontology ensures that technical contributions reported by SNS JU projects can be grouped, and traced all the way to their individual components, enabling clear relations to KVIs to be drawn in a comprehensive manner.

***Technology* class**

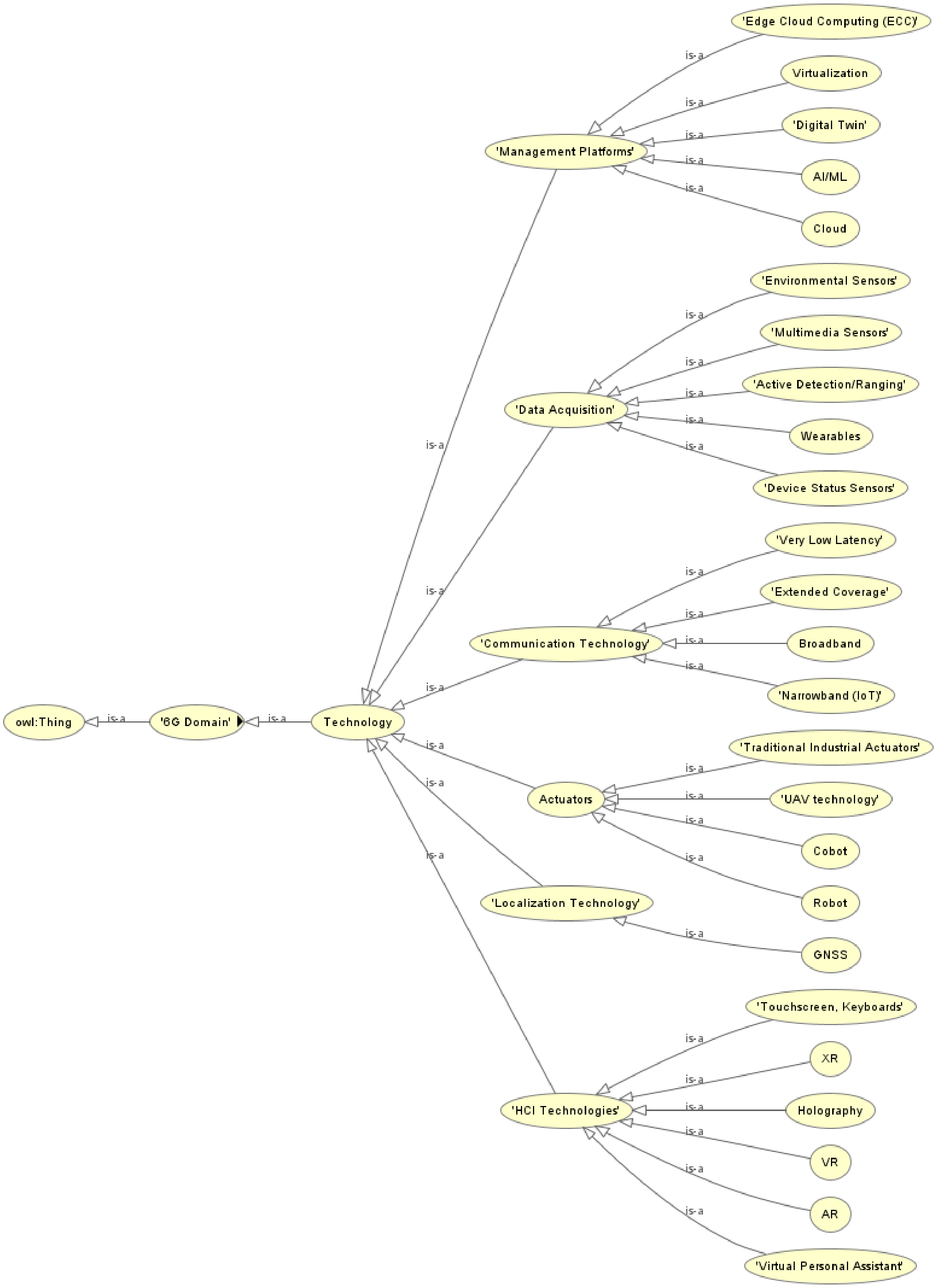

FIGURE 20: "TECHNOLOGY" CLASS

The “Technology” class (Figure 20) describes concrete 6G-related technologies that belong to a given Technology Domain. These may include, for example, distributed AI systems, THz radio components, network softwarisation modules, localisation techniques, or security mechanisms, based on published technology taxonomies [10], [14]. Technologies are linked to the domains they belong to and, crucially, to the capabilities they realise. This class operates at an intermediate level of abstraction: concrete enough to represent specific engineering artefacts yet abstract enough to remain stable as technologies evolve within ongoing SNS JU projects.

Designing the Technology class in this way allows different research initiatives to reference technologies consistently, even when terminology varies across projects or maturity levels. It also supports traceability: stakeholders can observe how a technology contributes to the value ecosystem by influencing capabilities, enabling enablers, or supporting KVIs. This modelling choice reflects guidance from existing structuring efforts in Hexa-X deliverables, 6G IA white papers, and the IMT-2030 vision, all of which emphasise the importance of linking technical assets to cross-domain outcomes. As such, the class provides meaningful, value-aware context for researchers and engineers without overwhelming the ontology’s conceptual model. Its object properties are presented in Table 22.

TABLE 22: OBJECT PROPERTIES OF "TECHNOLOGY" CLASS

Object Property	**Description**	**Range**
hasTechnologyDomain	A property that assigns each Technology to its broader Technology Domain.	Technology Domain
realisesCapability	A property indicating that a Technology enables or realizes a specific Technological Capability.	Technological Capability

***Technological Capability* class**

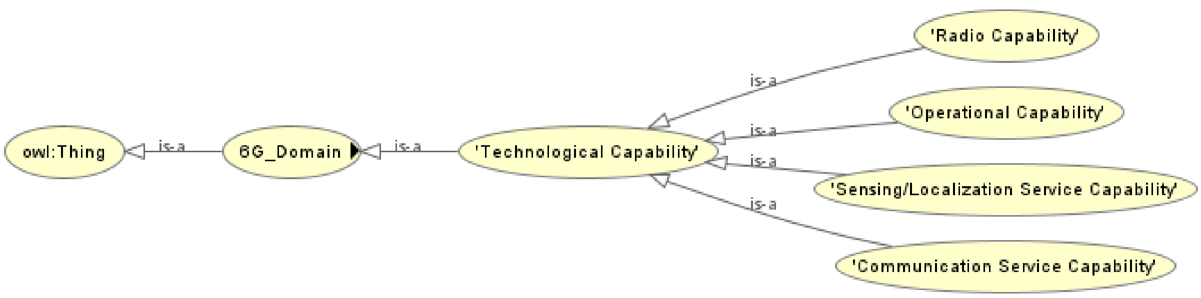

FIGURE 21: "TECHNOLOGICAL CAPABILITY" CLASS AND SUBCLASSES

The class “Technological Capability” and its subclasses (Figure 21) represent the next level of abstraction in the technological taxonomy, introducing the technical and sustainability requirements of a use case. This class represents widely recognised fundamental performance features or functional abilities of the 6G system [16], [17]. These are not specific technologies, but rather the system-level outcomes that technologies collectively enable (e.g., high reliability, ultra-low latency, accurate positioning). As a component in the ontology, Technological Capabilities play the role of linking lower-level technical components to high-level value and use case requirements: values, objectives, and more often use cases can be constrained or enabled by which capabilities can be delivered in practice.

They, therefore, provide a stable layer between evolving technologies and the socio-technical value system. For users, this class offers a clear vocabulary for discussing how technical performance translates into functional relevance. It also clarifies the distinction between performance outcomes (capabilities) and enabling mechanisms (enablers), supporting more traceable reasoning about how 6G can achieve given objectives or deliver on a particular KVI. Their link to Use Case is provided as an object property in Table 23.

TABLE 23: OBJECT PROPERTIES OF "TECHNOLOGICAL CAPABILITY" CLASS

Object Property	Description	Range
supportsTechnicalScenario	This capability contributes to enabling that ITU scenario.	Technical Scenario

Enabler class

The “Enabler” class and its network of subclasses, presented in Figure 22, represent the concept of architectural or system-level mechanisms (functions, features, design patterns) that realise technological capabilities based on specific technologies [18]. An Enabler therefore allows a capability to be delivered or improved. In the ontology, Enablers operate as the bridge between performance capabilities and value-based entities, as they describe how 6G systems are implemented in practice and which mechanisms support the achievement of values, KVIs, KSIs, and vertical-specific requirements. They advance the 5G-releated enablers described in [19].

This class is essential for many SNS JU projects that produce results at the level of “technical enablers” alongside or instead of use case deployments. For users from a technological background, this class offers a clear entry point to understand what technological means are needed to satisfy value-driven requirements and how technical features connect to measurable value indicators. It thus captures the architectural layer that sits at the top of the technical abstraction hierarchy and directly interfacing with the social, value, and sustainability dimensions of the ontology. Its object properties are provided in Table 24. Table 25 the data property linking a reported enabler to its TRL level within the context of the project that develops or reports it and is used for traceability across the value components.

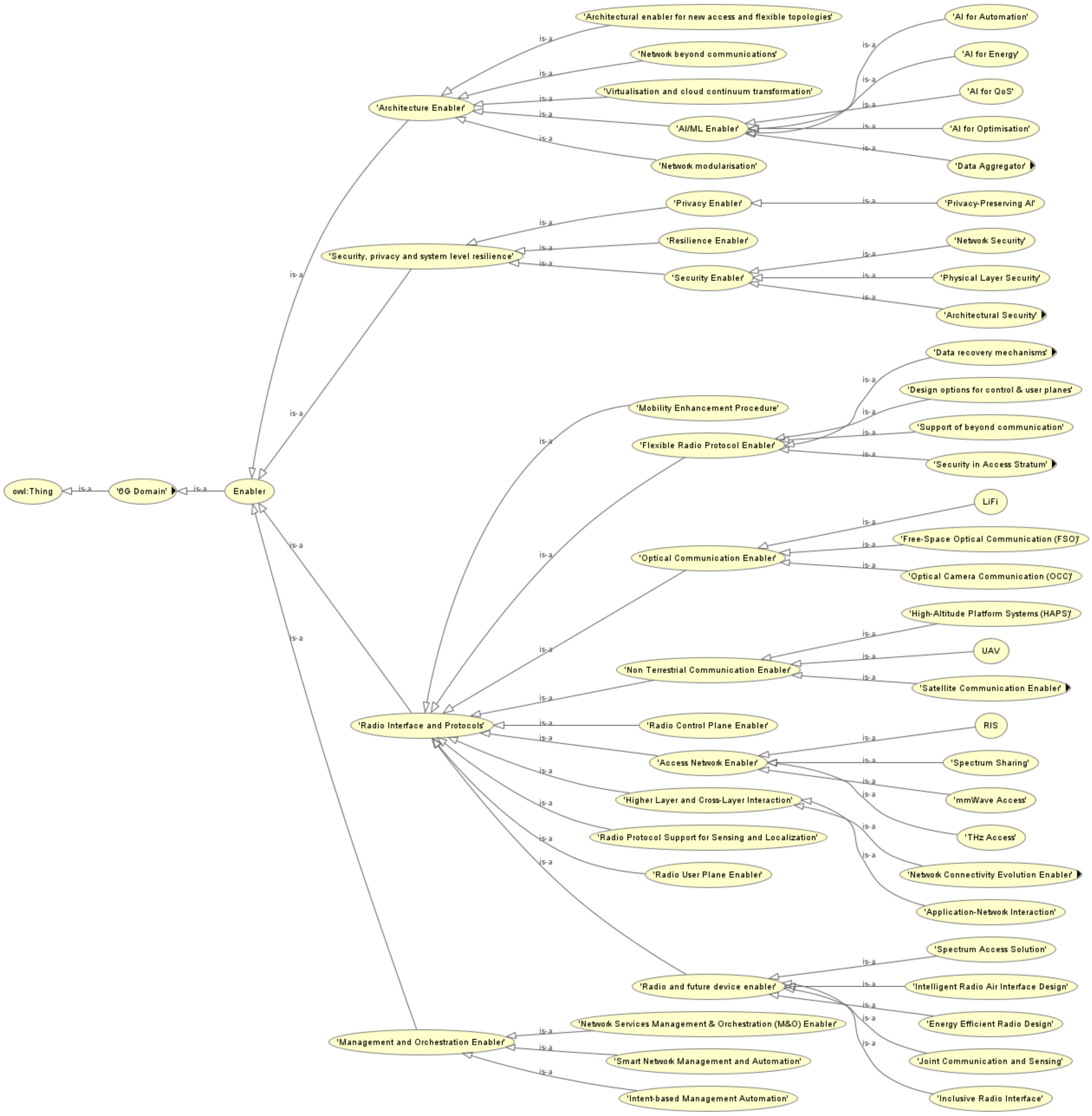

FIGURE 22: "ENABLER" CLASS AND SUBCLASSES

TABLE 24: OBJECT PROPERTIES OF "ENABLER" CLASS

Object Property	Description	Range
enablesIndicator	Is attributed to a factor, mechanism, resource, or condition (enabler) that facilitates or drives the achievement of a specific indicator	Indicator

enablesUseCase	A techonological or social enabler's tendency to optimize a distinct Use Case	6G Use Case
enablesCapability	A property indicating that an Enabler provides, supports, or implements a specific Technological Capability within the 6G system architecture.	Technological Capability
standardizedBy	Links a technological enabler to a standardisation body that has developped standards relating to it.	Standardisation Body
compliesWith	The subject conforms to a named Compliance Standard.	Compliance Standard
usesTechnology	A property describing the concrete technologies an Enabler requires or builds upon.	Technology
implementsPrinciple	Expresses that an enabler supports a Sustainability-by-design principle	SbDPrinciple

TABLE 25: DATA PROPERTIES OF "ENABLER" CLASS

Data Property	**Description**	**Range**
TRLLevel	Indicates the Technology Readiness Level of an enabler as assessed in the 6G development and deployment context.	Integer: 1-9

4.1.3.6 Auxiliary Sustainability & Governance Concepts

The classes presented in this subsection provide extra sustainability, governance, and policy grounding that completes the KVI Ontology and situates it within the broader ecosystem of 6G research, societal expectations, and international frameworks. While the earlier sections model the core entities (values, indicators, stakeholders, technologies, and use cases), these auxiliary concepts introduce the institutional and sustainability-oriented elements needed for a full value-based assessment. They add essential contextual information that aligns KVIs and KSIs with policy objectives, compliance requirements, and programme-level governance where such data is available. These classes ensure that the ontology as a framework acknowledges the sustainability mandates and operational realities shaping 6G value development and reports the concepts with an overarching layer of legitimacy and traceability, so that it can be useful to future researchers.

***Sustainable Development Goal (SDG)* class**

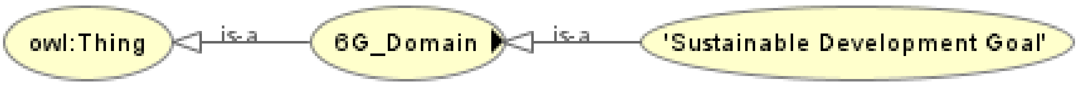

FIGURE 23: "SUSTAINABLE DEVELOPMENT GOAL" CLASS

The "Sustainable Development Goal (SDG)" class (Figure 23) represents the high-level global objectives defined by the United Nations that guide sustainable, equitable, and socially responsible development [20]. In the ontology, this class provides an external normative anchor that links 6G values and KVIs to these recognised sustainability priorities. It was included because several SNS projects explicitly reported or framed their KVIs in relation to specific SDGs, using them as reference points for articulating societal impact and sustainability alignment. By modelling SDGs as a dedicated class, the ontology accommodates this practice and provides a structured way to link project-level indicators to internationally recognised sustainability goals, maintaining consistency and comparability across the ecosystem. The class's identified object property is reported in Table 26.

TABLE 26: OBJECT PROPERTIES OF "SUSTAINABLE DEVELOPMENT GOAL" CLASS

Object Property	**Description**	**Range**
relevantReportedKVIs	A property relating a SDG to the reported KVIs that align with it	Integer: 1-9

***SbD Principle (Sustainability-by-Design Principle)* class**

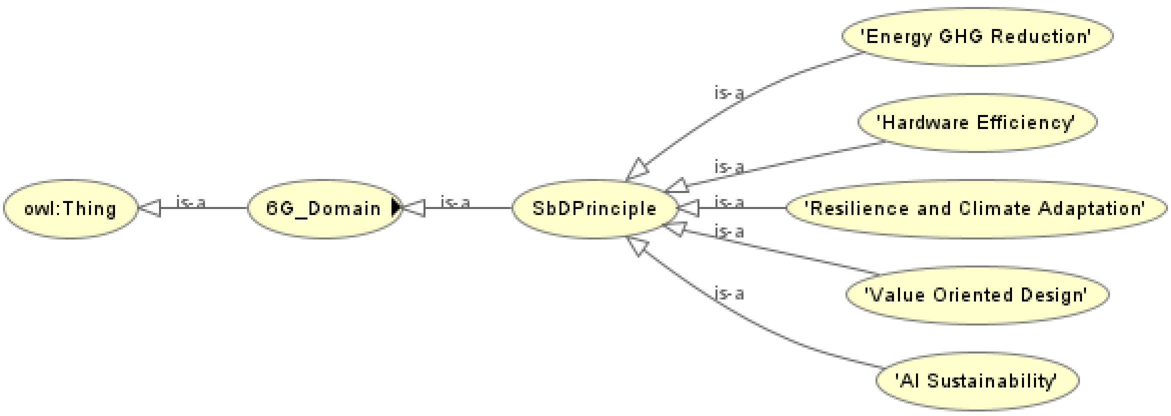

FIGURE 24: "SUSTAINABILITY-BY-DESIGN (SBD) PRINCIPLE" CLASS AND SUBCLASSES

The “Sustainability-by-Design (SbD) Principle” class and its subclasses (Figure 24) defines the foundational design-oriented sustainability concepts that can be associated with technologies, enablers, indicators, or use cases within the ecosystem. These principles capture how sustainability considerations should be embedded into 6G systems from the outset. In the ontology, SbD Principles act as higher-level normative descriptors that influence how technological components and assessments are interpreted, without prescribing specific metrics or indicators. By modelling these principles as a dedicated class, the ontology provides a structured way to link technical elements to the sustainability expectations that contemporary research and policy frameworks demand.

***Sustainability Practice* class**

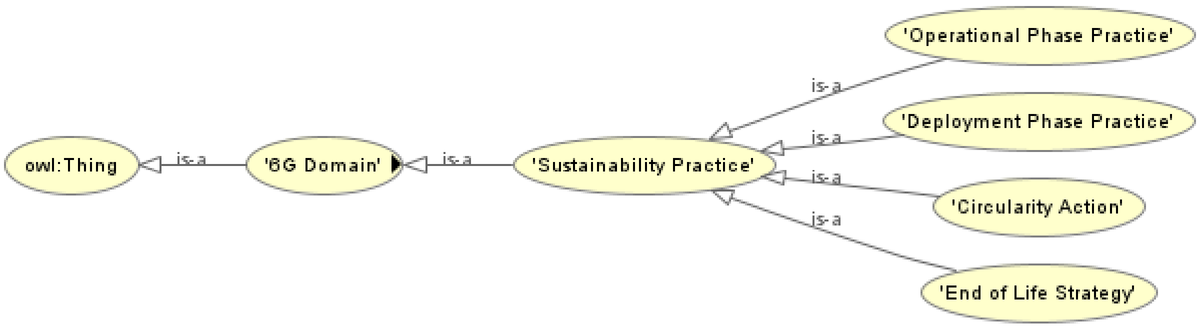

FIGURE 25: "SUSTAINABILITY PRACTICE" CLASS AND SUBCLASSES

The “Sustainability Practice” class, depicted in Figure 25, represents a high-level category of actions, strategies, or interventions that can be undertaken during the lifecycle of a 6G system in order to materialise sustainability objectives, like reducing environmental impact, enhancing circularity, or improving long-term sustainability outcomes. While Sustainability-by-Design Principles capture the intentions and conceptual commitments that should guide sustainable 6G development, Sustainability Practices describe the practical measures through which those intentions are implemented.

The inclusion of this class in the structure provides the ontology with the ability to represent how sustainability is operationalised in real projects. This provides actionable pathways for researchers, developers, and policymakers to understand and accurately report which interventions meaningfully support sustainability objectives, which stakeholders are responsible for them, and how they contribute to both KVIs and KSIs. In this way, they play a crucial role in the roadmap toward fully developed KSIs by outlining the conditions that future sustainability indicators will need to measure and evaluate. This class's object properties are reported in Table 27.

TABLE 27: OBJECT PROPERTIES OF "SUSTAINABILITY PRACTICE" CLASS

Object Property	Description	Range
compliesWith	The subject conforms to a named Compliance Standard.	Compliance Standard
appliesToUseCase	Indicates which use cases can or should incorporate the	6G Use Case

	sustainability practice as part of their design or evaluation.	
supportsAchievementOf	Connects a Sustainability Practice to a Key Value Indicator that it is intended to support or improve, by influencing the conditions that the KVI measures across the lifecycle of a 6G system.	KVI
enablesSustainabilityIndicator	Identifies the KSIs whose achievement is facilitated or supported by the implementation of a sustainability practice.	KSI
implementedVia	The practice is facilitated by an enabler	Enabler
performedByStakeholder	Identifies which stakeholder(s) are responsible for implementing the sustainability practice.	Stakeholder
realisesObjective	Links a sustainability practice to the strategic sustainability/value objective it helps realise.	Objective
supportsSustainabilityFeature	Specifies which sustainability feature a sustainability practice contributes to.	Sustainability Feature

***Aspect* class**

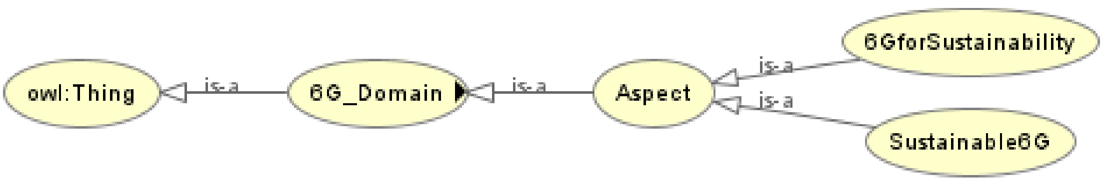

FIGURE 26: "ASPECT" CLASS AND SUBCLASSES

The "Aspect" class, represented in Figure 26, models a high-level categorisation of how 6G interacts with sustainability. Each Aspect describes a type of effect 6G has on environmental, societal, and economic sustainability. This class introduces an important distinction within the ontology because it separates two fundamentally different sustainability logics: making the 6G system itself more sustainable *(Sustainable 6G)* and using 6G technologies to advance sustainability in external sectors *(6G-for-Sustainability)*. It functions as a lightweight metadata layer that tags each reported use case with its sustainability orientation. This distinction, emphasized in multiple studies, is essential because it informs the user of the kind of sustainability contribution a use case is actually making, and therefore how it should be interpreted.

SNS JU Classes

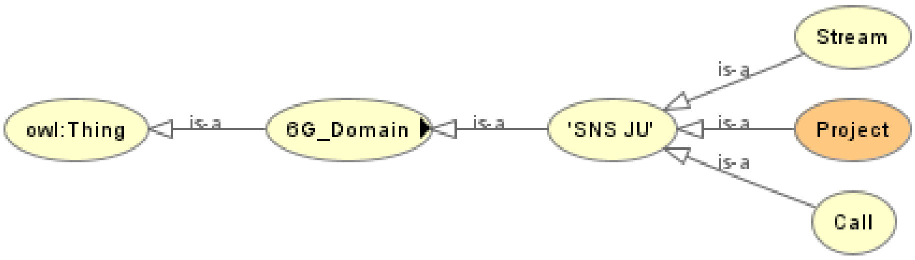

FIGURE 27: "SNS-JU" CLASS AND SUBCLASSES

The “SNS JU” class, and its three subclasses, “Call”, “Stream” and “Project” (Figure 27) form the governance layer of the ontology, enabling every value, indicator, use case, technology, or sustainability concept to be traced back to the specific SNS JU context in which it was developed. These classes mirror the structure of the SNS Work Programme: Calls launch funding rounds, Streams organised in thematic priorities, and Projects for the specific, concrete results. Collectively, they ensure that each reported Key Value, KVI, KSI, enabler, or use case can be linked to the initiative that defined it. Their inclusion allows users to understand where an entity comes from, which research effort produced it, and under what strategic priorities or funding conditions [17]. This provides transparency of the reported evidence by allowing users to trace concepts back to the projects, streams, and calls that shaped them, thereby offering richer contextual insight into how and why a given KVI or sustainability contribution was created.

Call class

The object properties related to the “Call” class are given in Table 28.

TABLE 28: OBJECT PROPERTIES OF "CALL" CLASS

Object Property	Description	Range
hasStream	Relates a Call to the Streams that are active in that Call, as defined in the SNS Work Programme.	Stream
hasFundedProject	Relates a Call to the projects it has funded.	Project

Stream class

The object properties of the "Stream" class are given in Table 29.

TABLE 29: OBJECT PROPERTIES OF "STREAM" CLASS

Object Property	Description	Range
streamOfCall	Relates a Stream to the Calls in which it is active.	Call
hasProject	Relates a Stream to the projects that belong to it.	Project

Project class

The object properties of the "Project" class are given in Table 30.

TABLE 30: OBJECT PROPERTIES OF "PROJECT" CLASS

Object Property	Description	Range
fundedUnderStream	Each project is assigned by the SNS JU to a specific Call within the sequence of Work Programme funding rounds.	Call
fundedUnderStream	Links a Project to the Stream in which it is defined and used.	Stream
targetsKeyValue	The project targets or intends to contribute to a specific Key Value.	Key Value
contributesToKVI	Relates a Project to the KVIs to which it provides evidence, results, or contributions.	Key Value Indicator
focusesOnVertical	Refers to a Project's targetted vertical sectors.	Vertical Sector
hasUseCase	It expresses that a given project is associated with,	6G Use Case

	focused on, or provides results for a specific 6G use case.	

Compliance Standard **class**

Finally, the "Compliance Standard" class represents formal technical or regulatory standards that certain technologies or practices may conform to. It is included primarily for completeness, as only limited data exist at present and most information relates to enabling technologies. Because this domain is rapidly evolving and new governance and network standards continue to emerge, the class provides a flexible placeholder that can be expanded as future SNS projects reference additional norms or compliance requirements.

4.1.4 Validation

To assess whether the KVI Ontology meets its intended purpose and satisfies the requirements defined in the ORSD, a set of Competency Questions (CQs) has been developed as part of the validation process. Competency Questions provide a practical way to test the ontology's ability to retrieve meaningful information and effectively ensure that its structure, classes, and relations support the types of queries users are expected to perform. They ensure that the ontology captures the relationships necessary to support meaningful reasoning across values, indicators, stakeholders, technologies, and use cases. Within the NeOn methodology, these questions act both as a design compass (preventing unnecessary complexity) and as a verification instrument after implementation. The ontology is considered correct and fit for purpose to the extent that it can respond to these competency questions through its classes, object properties, and data structures.

These questions can be operationalised within Protégé through DL Query or SPARQL (via plugins such as the SPARQL Tab), allowing users to explore how Key Values, Indicators, Stakeholders, Operational Concepts, Enablers, and Technological Capabilities interrelate. For example, users can test whether the ontology correctly identifies all KVIs associated with a given Key Value, retrieves relevant stakeholders, or traces how a technological capability supports specific operational or value-related outcomes.

Because the ontology covers a broad and very ambitious range of concepts but is used within a rather small 6G4Society lifecycle, the current validation exercise focuses on the first four layers of the ontology (key concepts, indicators, stakeholders, operational). These layers capture the most critical elements for value alignment and analysis, and the mapping of indicators to use cases and enablers, which fulfils a primary focus of the project. The lower technical layers are intentionally less populated in this version of the ontology and therefore remain outside the scope of this CQ set. The questions presented are not exhaustive. They are rather indicative of the kinds of insights users can extract from the ontology and demonstrate the functionality and coherence of the model. They also reflect the varying needs of different user groups: researchers may query conceptual consistency, engineers may focus on enabler-to-value mappings, and policymakers may interrogate stakeholder impacts. By applying these competency questions in Protégé, users can confirm that the ontology supports meaningful exploration of the 6G value landscape and that it performs as a robust semantic reference model.

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TABLE 31: COMPETENCY QUESTIONS ADDRESSING THE ONTOLOGY'S FOUNDATIONAL CONCEPTS

	Foundational Concepts
CQ1	What Key Values are important in 6G?
CQ2	How is each Key Value classified within the sustainability pillars?
CQ3	Which Stakeholders are affected by a given Key Value?
CQ4	Which KVIs operationalise a given Key Value?
CQ5	What types of KVIs are linked to a Key Value?
CQ6	What Assessment Style is associated with the KVIs of a given Key Value?
CQ7	Which KVI Dimensions classify the indicators under a given Key Value?
CQ8	Which Objectives are associated with or support a given Key Value?
CQ9	Which Impacts are linked to a Key Value through its indicators?
CQ10	What are the associated Impact Likelihood and Impact Severity values of impacts linked to a Key Value?
CQ11	Which Stakeholders are affected by the KVIs of a given Key Value?
CQ12	What stakeholder priority labels are assigned to Stakeholders affected by a Key Value?
CQ13	Which 6G Use Cases provide evidence or measurements relevant to a given Key Value?
CQ14	Which Vertical Sectors emphasise or prioritise a Key Value?
CQ15	Which Enablers support the achievement of a Key Value through their associated KVIs?
CQ16	Which SDGs relate to a Key Value through its indicators?
CQ17	Which SNS JU Projects target or address a given Key Value?

TABLE 32: COMPETENCY QUESTIONS ADDRESSING THE ONTOLOGY'S INDICATOR CONCEPTS

	Indicator Concepts
CQ18	Which KVIs exist for a particular Key Value?
CQ19	Which KVI Dimensions classify a given KVI, and what interpretive lens does this dimension provide?
CQ20	What Indicator Purpose is associated with a KVI, and how does this purpose influence its interpretation?
CQ21	Which Assessment Style (qualitative, quantitative, mixed) is assigned to the KVI, and what are the implications for how it can be measured or compared?
CQ22	Which Key Values does a KVI operationalize?
CQ23	Which Objectives are measured or supported by a KVI, and does the KVI connect to multiple objectives?
CQ24	What Impacts are linked to a KVI, and what is their associated likelihood and severity?
CQ25	Which Sustainability Features were present to enable this KSI to evolve from a KVI?
CQ26	Which KSIs reinterpret or extend this KVI?
CQ27	Which SDGs align with the KVI?

CQ28	Which Vertical Sectors rely on or prioritise this KVI?
CQ29	Which stakeholder groups are affected by this KVI, and what priority label is assigned to each stakeholder in relation to it?
CQ30	Which Enablers support the achievement of the KVI, and what is the TRL level of each Enabler?
CQ31	Which Technological Capabilities are required for the KVI to be realised?
CQ32	Which SNS JU Projects report, use, or generate evidence for this KVI?

TABLE 33: COMPETENCY QUESTIONS ADDRESSING THE ONTOLOGY'S STAKEHOLDER CONCEPTS

	Stakeholder Concepts
CQ33	Which Stakeholder groups are represented in the ontology?
CQ34	Which Key Values affect a given Stakeholder group?
CQ35	Which KVIs involve or impact a specific Stakeholder group?
CQ36	What stakeholder priority label (Primary, Secondary, Peripheral) is assigned to a Stakeholder in relation to a Key Value?
CQ37	Which Stakeholders are responsible for measuring or influencing a KVI?
CQ38	Which Stakeholders are responsible for implementing a Sustainability Practice?
CQ39	Which Stakeholders contribute to realising specific Objectives?
CQ40	Which Stakeholders are involved in or affected by a given 6G Use Case?
CQ41	Which Sustainability Features or KSIs relate to Stakeholders through their associated KVIs?
CQ42	Which Sustainability Practices require participation or action from specific Stakeholder groups?
CQ43	Which SNS JU Projects affect a given Stakeholder group through the KVIs they report?

TABLE 34: COMPETENCY QUESTIONS ADDRESSING THE ONTOLOGY'S OPERATIONAL CONCEPTS

	Operational layer Concepts
CQ44	Which 6G Use Cases are represented in the ontology?
CQ45	Which Use Case Family/ies classify a particular Use Case?
CQ46	Which Technical Scenarios relate to a specific Use Case?
CQ47	Which KVIs does a Use Case provide evidence for?
CQ48	Which Key Values are indirectly addressed by a Use Case through its associated KVIs?
CQ49	Which value-related Impacts are linked to a Use Case through the KVIs it evidences?
CQ50	Which Vertical Sectors a Use Case belongs to or is relevant for?
CQ51	Do multiple Vertical Sectors share the same Use Case?
CQ52	Which Sustainability Features or Practices relate to a given Use Case (via KVIs)?
CQ53	Which SNS JU Projects develop or report a specific Use Case?
CQ54	Which Use Case Families are included in the ontology?

CQ55	Which Use Cases belong to a given Use Case Family?
CQ56	Which Key Values or KVIs dominate within a particular Use Case Family?
CQ57	Which Technical Scenarios are most relevant to a given Use Case Family?
CQ58	What Technical Scenarios exist in the ontology?
CQ59	Which Use Cases correspond to a Technical Scenario?
CQ60	Which Enablers or Technological Capabilities are required for Use Cases in a given Technical Scenario?
CQ61	Which Vertical Sectors are represented in the ontology?
CQ62	Which Use Cases operate in or target a specific Vertical Sector?
CQ63	Which Key Values are most relevant to a Vertical Sector, based on importance indices and associated KVIs?
CQ64	Which Enablers support a given Vertical Sector
CQ65	Which Technological Capabilities are needed in this Vertical Sector through associated enablers?
CQ66	Which KSIs or sustainability features relate to a given Vertical Sector?
CQ67	Which SNS JU Projects focus on a particular Vertical Sector?

4.2 Contributions to Standardisation

4.2.1 Contribution to a CEN Workshop Agreement (CWA)

4.2.1.1 Overview of the CWA

In the context of 6G4Society's ambition to deliver a coherent, reusable and consensus-driven framework for value-based 6G assessment, the CEN Workshop Agreement (CWA) "6G4Society: Key Value Indicator (KVI) Framework for Sustainable and Human-Centric 6G Development" was positioned as the project's main pre-standardisation outcome, representing a major achievement as it translates the consortium's methodological and ontological work into an officially recognised, openly accessible reference for the broader 6G ecosystem. This CWA focuses on Key Values and KVIs and translates the project's KVI work into a reusable, institutionally recognised asset for the wider 6G ecosystem. It formalises both a methodology for deriving and reporting KVIs and a normative core ontology that encodes how values, indicators, technical enablers and stakeholders interrelate in 6G research and development.

The CWA specifies a common methodology and a normative core ontology for structuring, reporting and aligning Key Values (KVs) and KVIs in the context of 6G research. It organises Key Values under the three sustainability dimensions (societal, environmental and economic) and defines how KVIs must be documented in terms of evidence, stakeholder relevance and reporting requirements. The ontology is provided in RDF/OWL, with a minimum vocabulary and conceptual model that can be extended by domain-specific modules.

Rather than prescribing a fixed list of indicators or thresholds, the CWA standardises how KVIs are defined and reported: it sets the minimum information model, terminology and relationships that make value-based assessment interoperable across projects and verticals.

At the heart of the CWA is a value realization path in the form of an ontology that explicitly encodes the chain Key Value → KVI → Enabler → Use Case → KPI → Stakeholder. The ontology requires each KVI to be anchored in a parent Key Value and sustainability dimension, linked to the technical enablers and use cases through which it is realised, and connected to underlying KPIs that provide measurable technical grounding. Stakeholders (e.g. policymakers, operators, end-users, civil society) are modelled as beneficiaries, evaluators or decision-makers using KVI evidence.

This value chain design is operationalised through:

- **KVI design principles** (reporting the identified features of “good” KVIs, explicit KV–KVI links, evidence classes, scope levels).
- **A normative core vocabulary** of classes and properties and the minimum relations that must be provided for the model to remain usable and extendable.
- **A set of profiles and mapping workflows** (project, use-case, enabler and stakeholder profiles) that standardise the value reporting procedure for different entry points in the style of “if you are X, you must report Y in this format”, in provided templates.

To balance stability with the evolving 6G research landscape, the CWA splits the ontology into:

- a normative core (mandatory classes, properties and constraints), and
- informative extensions (example KVIs, enabler lists, use-case families, stakeholder taxonomies) that can evolve as projects contribute new evidence.

This architecture provides an immediately usable harmonisation layer while leaving space for iterative additions and sector-specific specialisation.

The CWA is designed to respond to the concrete problem identified across SNS JU projects: KVIs are currently defined and used in highly heterogeneous ways, with varying definitions, granularity and maturity levels, which makes results difficult to compare or aggregate. By standardising the method and information model rather than presenting a fixed list of indicators, the CWA enables cross-project comparability of value-related results and a method for traceability from high-level values to technology aspects. It also concretely attempts to stir more robust standardisation discussions around societal and sustainability impacts, targeting and benefitting in turn policymakers, industry, standardisation organisations, researchers and civil society.

Against this background, 6G4Society initiated and co-authored the CWA for three main reasons:

1. **To formalise and stabilise the KVI methodology as a pre-standard.** The project had already contributed a common approach to Key Values, KVIs and KSIs through a bottom-up, consensus-driven process. The CWA is the natural next step: it turns these project-level results into normative guidance, giving the KVI work institutional visibility and a recognised reference status within the European standards landscape.
2. **To provide a shared backbone for SNS JU and future 6G initiatives.** 6G4Society is actively engaged in SNS Working Groups (SNVC, TMV, Sustainability Task Force, Pre-Standardisation WG) and has repeatedly encountered the need for a common value vocabulary and a structured way of linking values to indicators, technological enablers and trials. The CWA responds directly to these programme-level recommendations by offering a single, shared value-chain model that other projects can adopt or extend.
3. **To support exploitation of the KVI Ontology beyond the project.** The KVI Ontology has already been positioned as a key asset for both research and policy/standardisation exploitation, including hand-over to the Sustain-6G project and use in future SNS JU calls. The CWA is a cornerstone of this strategy as it makes the ontology easier to adopt by external actors.

In short, the CWA is a central exploitation pathway, since it turns the project's conceptual and ontological work into an authoritative reference that can be reused, extended and tested well beyond the project lifetime.

4.2.1.2 CWA procedure

The CWA process consists of three main phases. These are the initiation, operation, and publication phase. Each one is governed by rules defined in CEN-CENELEC Guide 29. The process is intentionally lightweight compared to formal standardisation allowing for faster adoption times, but still rigorous enough to guarantee structured input and transparent decision-making. The official timeline includes:

1. Submission of the Workshop Description Form, triggering the formal establishment procedure.
2. Open public commenting on the Draft Project Plan (30 days), allowing any interested organisation or individual to provide input or request participation.
3. Workshop Kick-off Meeting, during which participants are formally constituted, the project plan is adopted, roles are assigned, and the development work begins.
4. Drafting and iterative refinement of the CWA, supported by the Workshop Chair and Secretariat.
5. Consensus-based approval of the final CWA by the registered Workshop participants.
6. Publication and dissemination of the CWA via CEN/CENELEC and project communication channels.

A set of functional roles and working structures is defined by CEN that collectively form the authority basis during the consultation and drafting phases. The process states that during the 30-day open commenting phase, any interested party may request participation. All organisations approved at the kick-off meeting become Workshop Participants, gaining full rights to contribute to drafting, comment on all sections of the CWA, influence the scope and methodology, and vote on the final text.

In line with the CEN/CENELEC Workshop procedure, the 30-day public consultation period is intended to give all interested stakeholders the opportunity to comment on the draft project plan before the Workshop is formally constituted. However, given the maturity of the material already produced within the 6G4Society project, including the consolidated KVI methodology, the multi-project surveys and the normative core ontology developed under WP4, the consortium is in a position to advance the drafting of the CWA text in parallel with the consultation phase. This approach is justified because the substantive inputs required for the CWA (methodology, conceptual model, minimum vocabulary, reporting templates) have already been generated and refined through project lifecycle activities, stakeholder engagement, and cross-project harmonisation efforts. Running drafting and consultation concurrently therefore does not compromise the openness or transparency of the process. Instead, it shortens the overall timeline, ensures that the kick-off meeting can move quickly to content alignment rather than starting from a blank page, and enables the Workshop to deliver the CWA within the timeframe of the project. The consensus-building and formal approval steps still take place after the Workshop is constituted, but the availability of a near-complete draft ensures that participants can focus on reviewing, refining and validating the document.

While the consortium considers the risk of major scope divergence to be low given the maturity and prior external validation of the material, it is acknowledged that the open consultation may introduce new perspectives or priorities. To address this, any substantive comments received during the consultation or raised by newly admitted Workshop Participants will be formally reviewed once the Workshop is constituted. Where necessary, the draft will be revised, rescoped, or phased to ensure alignment with consensus-based decision-making, in line with CEN Workshop governance principles. The requirement for consensus is respected, and the NOVA, as the Workshop Chair will ensure that externally driven inputs are transparently integrated into the drafting process.

The **Workshop Chair** acts as the primary coordinator of content-related activities during the consultation period. Their responsibilities include managing the consensus-building process, ensuring alignment with the agreed scope, resolving comments and representing the Workshop externally. In our case, the WS Chair position is covered by the NOVA team.

The **Workshop Secretariat** is an official member provided by CEN or CENELEC. Their role is to manage all administrative and organisational aspects, the conduct of the open commenting procedure, and compliance with CEN/CENELEC rules and Guide 29.

The **Workshop Description Form (WDF),** submitted by the WS Secreatriat identifies a number of CEN and CENELEC Technical Committees and coordination groups that are potential candidates to provide interest, review or align opportunities during the consultation stage. For the 6G4Society CWA, the committees considered were the following:

- CEN SS S29 – Social Responsibility,
- CEN/TC 391 – Societal and Citizen Security,
- CEN/TC 465 – Sustainable Urban & Community Development,

These bodies represent important external alignment channels, helping ensure that the CWA does not conflict with existing standards work and can later connect to sector-specific or regulatory frameworks.

4.2.2 Pre-Standardisation WG Contributions

The Pre-Standardisation Working Group (WG) within the SNS JU ecosystem is the main standardisation link in programme level. It provides an early coordination space where research projects share methods, identify gaps and explore how their outcomes can support future European and international standardisation activities. Its work focuses on bridging the distance between research results and the formal processes of the official bodies, such as CEN/CENELEC, ETSI, ITU-T and 3GPP. In the 6G4Society context, this WG was particularly relevant because it offers a platform to position our value-oriented and societal impact-focused approaches at a stage where conceptual frameworks and methodological choices are still flexible. Participation in this group enabled the project to ensure that our results are aligned with broader pre-standardisation priorities and recognised as assets for broader harmonisation.

Through our participation in the WG's ongoing discussions, it became clear that several concrete gaps in the pre-standardisation landscape uniquely positioned 6G4Society to help address the challenges of integrating societal values and sustainability considerations into early 6G work. Many participants openly highlighted a recurring disconnect between high-level principles and actual technical practice. They also noted that current KVI definitions often lack contextual awareness: indicators that make sense in one jurisdiction or sector may not apply elsewhere, yet there are no mechanisms to adapt or translate them to specific regulatory, cultural or operational settings. This makes KVIs difficult to operationalise and limits their usefulness when moving towards technical requirements. As a consequence, sustainability, and particularly the links between technology and its societal, environmental and economic implications, is still not systematically incorporated in early technical discussions. Key concepts such as resilience, privacy, security and energy efficiency tend to be addressed narrowly from a technical standpoint or only considered late in the process. The discussions further revealed uncertainty about the sustainability impacts of AI-intensive 6G architectures and the lack of shared methods to assess them. Across the WG, it was also observed that engineering work continues to prioritise traditional technical KPIs, which often leaves societal and sustainability issues outside the main development flow, resulting in architectures that do not consistently reflect meaningful use cases or stakeholder needs.

During the WG meetings, 6G4Society presented the KVI Ontology as a central contribution to addressing the methodological and semantic fragmentation identified across SNS JU projects. The ontology was introduced as a practical mechanism and a tool for translating societal values and sustainability considerations into structured, technically relevant components. The presentation focused on clarifying the rationale behind the ontology, outlining its core objectives, demonstrating its evolving structure, and explaining the engineering methodology used for its development. Emphasis was given into presenting the mapping of technological enablers, as the closer in scope to the group's expertise.

The exchanges within the Pre-Std WG offered valuable lessons for how our project's outcomes can be more effectively integrated into early 6G development, and they generated concrete recommendations. A recurring lesson was that there is still a significant gap between value-based principles and day-to-day technical practice. Based on this insight, several recommendations emerged. First, projects need structured tools and semantic models, such as the proposed KVI Ontology, to support the translation of values into actionable indicators. Second, KVI definitions should be developed with built-in mechanisms for contextualisation, so that they can facilitate adaptation to operational environments. Third, there is a need to explore integration points within 6G architecture where KVI-related rules could be embedded directly using policy languages like XACML or ODRL, already employed in policy contexts. Fourth, early engagement with engineers is essential to ensure that values are considered in system design rather than introduced only as retrospective evaluation criteria. Finally, WG discussions underscored the importance of cross-project coordination to avoid duplicating effort and to build a coherent foundation for pre-standardisation activities.

The Pre-Std WG also provided an important link between SNS JU activities and emerging 3GPP discussions on 6G. Through the regular meetings and contributions, 6G4Society helped articulate how value-driven and sustainability-oriented considerations could complement the technical priorities identified in the 3GPP regular meetings, which emphasised sustainability, resilience, security, energy efficiency, and AI-native network design as central themes for Releases 20 and 21. The ontology was therefore positioned as a complementary mechanism to help 3GPP members reason about non-technical factors within the broader landscape of 6G design considerations.

Overall, 6G4Society's engagement in the Pre-Std WG strengthened the visibility and relevance of our designed value-based methodologies within the early stages of 6G standardisation. The project's contributions helped highlight structural gaps in the treatment of societal and sustainability factors and managed to propose a concrete, technically oriented solution in the form of the KVI Ontology. These discussions not only validated the need for a harmonised approach to values and indicators across the SNS ecosystem but also opened pathways for connecting these methods to our CWA activity and indirectly influence 3GPP study items. As a result, the project was recognised within the WG as a key contributor capable of bridging conceptual value frameworks with emerging technical needs.

4.2.3 ETSI Contributions

The 6G4Society pre-standardisation roadmap recognised that major standards bodies operate on tight technical committee timelines, making entry points difficult, especially for a project whose mandate revolves around "soft" contributions. This required our approach to shift to prioritise pre-standardisation influence over direct specification influence. Against this background, and although initial discussions were opened with two technical committees, our most effective contribution to ETSI in this period was achieved through the 2025 Security Conference and the active participation in a series of online workshops and webinars. This approach provided a realistic and strategically aligned pathway for introducing and discussing 6G4Society's work within ETSI, while fully respecting the procedural constraints and strict timelines of the formal technical committees.

4.2.3.1 ETSI Security Conference 2025

ETSI plays a central role in shaping European frameworks for emerging 6G technologies, making it an essential venue for positioning 6G4Society's work on societal values and KVIors. As part of this engagement, the project contributed to the ETSI Security Conference 2025, an event bringing together industry, policymakers, researchers and standards experts to discuss future-oriented approaches to security in next-generation networks. This conference provided a unique opportunity to showcase how value-driven methods can complement and strengthen security standardisation efforts.

We delivered a presentation titled "Beyond performance: Structuring 6G security around societal needs and values", introducing security not only as a technical feature but as a multidimensional societal value that encompasses accountability, trust, safety and user wellbeing. The presentation demonstrated how the KVI Ontology enables traceability from user needs to system objectives and ultimately to specifications. We essentially framed security through KVIs such as user trust perception, accountability mechanisms, and resilience outcomes, through which we illustrated how values can be operationalised in ways that are meaningful to technical stakeholders.

The presentation was well received by the conference audience and generated a series of in-depth discussions with representatives from different sectors and ETSI member organisations. Participants expressed strong interest in how KVIs could clarify security objectives, balance societal expectations with technical constraints, and help navigate trade-offs. The talk prompted several exchanges on how the ontology's ability to support interoperability and present the gaps in existing KPIs could strengthen ETSI's own work on security and governance in 6G. This engagement proved effective, as it enabled the project to surface its approach at the right maturity level, to validate it with cross-sector ETSI experts, and to prepare the ground for later uptake. In this way, our participation has built credibility for future standardisation phases.

This contribution helped measure the project's methodology against a technical standards environment, demonstrating its relevance and applicability to real-world security issues faced by practitioners and standards architects. We advocated for KVIs as structured, testable entities, highlighting their potential to support ETSI in addressing security as a societal outcome, not merely as a technical feature.

FIGURE 28: G4SOCIETY TEAM PRESENTING THE PROJECT'S SECURITY VALUE AND KVI ONTOLOGY AT THE ETSI SECURITY CONFERENCE 2025

4.2.3.2 ETSI Webinars

In addition, 6G4Society actively participated in a series of open-access ETSI webinars throughout 2025. These sessions provided opportunities to monitor emerging technical priorities, gather insights on ongoing pre-standardisation activities, and assess how value considerations could find a way to align with the evolving technical landscape. Attendance allowed the project to directly engage with the broader ETSI community, understand domain-specific developments, and evaluate where sustainability/value frameworks could meaningfully contribute in future phases of standardisation.

- **ETSI ISAC Use Cases Webinar:** With an objective to provide an overview of emerging Integrated Sensing and Communication (ISAC) use cases for 6G and outline how 3GPP is progressing service requirements for Release-20 and beyond, with scenarios spanning collaborative robotics, UAV transport, industrial automation, public safety, NTN sensing and infrastructure monitoring.
  - The discussion revealed that 6G ISAC use cases remain in an exploratory phase and that requirements precede measurable KPIs, meaning standardisation is still open to conceptual contributions. Key insights included:
    - Growing importance of AI-assisted sensing and data fusion across heterogeneous sources
    - Recognition that trust, interpretability and quality of sensing are central challenges, not only technical performance (trust of the information is also part of the quality)
    - Need to differentiate between indoor and outdoor deployments, affecting the societal and safety implications of use cases
    - Absence of a dominant "killer use case," implying that value-driven criteria may influence prioritisation in future phases. These findings turned the KVI Ontology's outlook to potentially map societal expectations to ISAC-related enablers

- **OpenSlice Release 2025Q2 Webinar:** Showcased the 2025Q2 release of OpenSlice, focusing on orchestration, service lifecycle management, APIs for network slicing, and alignment with ETSI principles.
    - Discussions emphasised automation, interoperability and standardised APIs. These themes intersect directly with value-driven requirements such as resilience, accountability, and transparency connected to societal concerns. The session clarified potential architectural points where indicators linked to user control or quality of service experience could be connected to orchestration and slice assurance processes.
- **Channel Characterisation and RF Hardware Models for THz Communications:** Presented the state-of-the-art in THz propagation modelling, RF impairments, and hardware characterisation for ultra-high-frequency communications. Emphasised requirements for channel modelling, antenna design, and physical-layer constraints.
    - THz research is progressing rapidly but remains technically driven, with limited consideration of the societal or sustainability impacts of high-frequency deployment. This highlighted a potential future need to connect THz technology enablers with value indicators reinforcing their relevance in technical discussions.

- **CRA Standards Unlocked – Opening Public Consultation:** To explain the upcoming Cyber Resilience Act (CRA), clarify the scope of digital product requirements, and present the structure of the ongoing public consultation on conformity assessment, vulnerability handling and security-by-design obligations.
    - The session strengthened the link between security as a societal value and emerging regulatory frameworks. The CRA focuses on accountability, transparency, and lifecycle security and aligns closely with several identified KVIs.

5 CONCLUSIONS

The 6G4Society project has demonstrated the relevance and innovation potential of its outcomes through the definition and refinement of multiple KERs across domains such as sustainability assessment, socio-technical governance and value-driven frameworks. This final exploitation report provides a structured overview of these results, their maturity levels and the pathways identified for sustaining and extending their use.

In addition to individual exploitation strategies, the deliverable introduces two forward-looking initiatives: the Competence Centre and Pool of Experts, which aim to preserve the project's legacy and offer structured mechanisms for ongoing support, dissemination and collaboration within the SNS community. Although these are not funded within the current project scope, their conceptual development sets the foundation for future uptake and resource mobilisation.

The findings and exploitation strategies documented herein are intended to inform both the 6G research community and future SNS JU initiatives. They offer actionable insights into how social, ethical and sustainability considerations can be embedded into next-generation network design and deployment. Continued stakeholder engagement and alignment with policy and industry priorities will be essential to realising the long-term impact envisioned by 6G4Society.

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