Grant Agreement No.: 101139070 (SNS JU)
www.doi.org/10.5281/zenodo.18258741

6G4SOCIETY

D1.3 Towards a socially accepted and sustainable 6G

Operational Brief

Work package	WP1
Task	Task 1.4
Due date	31/12/2025
Submission date	15/01/2026
Deliverable lead	CSL
Version	1.0
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Abstract	This deliverable presents a set of four Operational Briefs developed within the 6G4Society project to support industry actors in addressing societal, ethical, and sustainability-related challenges arising in the development and deployment of future 6G networks. Building on a consolidated analysis of societal concerns, risks, and governance gaps, the document translates these insights into industry-facing operational guidance, addressing how societal values such as privacy, inclusion, technological sovereignty, and sustainability can be embedded into concrete

Co-funded by the European Union

Project funded by
Schweizerische Eidgenossenschaft
Confédération suisse
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Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

industrial practices, technological choices, and innovation processes.

The four Operational Briefs adopt a shared analytical approach, translating societal concerns into operational risks, identifying gaps in current practices and governance arrangements, and articulating context-sensitive operational options for industry stakeholders. Together, they highlight that achieving a socially accepted and sustainable 6G is not primarily a technical challenge, but an operational and governance-related one.

Keywords 6G, social acceptance, sustainability, societal values, governance, privacy, inclusion, technological sovereignty, Responsible Research and Innovation (RRI), operational guidance, ethical foresight, digital transformation, public participation.

DOI 10.5281/zenodo.18258741

www.doi.org/10.5281/zenodo.18258741

Document Revision History

Version	Date	Description of change	List of contributor(s)
V0.1	01/09/2025	Initial ToC	Carmela Occhipinti (CSL)
V0.2	22/10/2025	Sections 1, 2	Carmela Occhipinti (CSL)
V0.3	15/11/2025	Four Operational briefs	Carmela Occhipinti, Lucas Pereira Carwile, Margot Bezzi (CSL)
V0.4	23/12/2025	Document finalisation	Carmela Occhipinti (CSL)
V0.5	10/01/2026	Ready for internal peer review	Carmela Occhipinti (CSL), Lucas Pereira Carwile, Margot Bezzi (CSL)
V0.6	10/01/2026	Integrated peer review feedback	Carmela Occhipinti (CSL), Margot Bezzi (CSL)
V1.0	15/01/2026	Final Version	Carmela Occhipinti (CSL)

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6G4SOCIETY project has received funding from the Smart Networks and Services Joint Undertaking (SNS JU) under the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101139070. This work has received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Project co-funded by the European Commission in the Horizon Europe Programme		
Nature of the deliverable:	Report	
	Dissemination Level	
PU	*Public, fully open, e.g. web (Deliverables flagged as public will be automatically published in CORDIS project's page)*	✓
SEN	*Sensitive, limited under the conditions of the Grant Agreement*	
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Classified C-UE/ EU-C	*EU CONFIDENTIAL under the Commission Decision No2015/ 444*	
Classified S-UE/ EU-S	*EU SECRET under the Commission Decision No2015/ 444*	

* R: Document, report (excluding the periodic and final reports)
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

This deliverable, *D1.3 Towards a socially accepted and sustainable 6G. Operational Brief*, targets **industry actors, researchers and technology developers, infrastructure providers, and multi-actor innovation ecosystems** involved in shaping the future of 6G. In particular, this work builds on the policy briefs elaborated in [1] translating policy-oriented analyses and insights into Operational Briefs with **industry-facing concrete and operational guidance**.

This work builds on the same **empirical evidence and stakeholder engagement** as [1], drawn from sustained interaction with the Smart Networks and Services Joint Undertaking (SNS JU) community through participatory workshops, a survey of SNS JU projects, and expert interviews, and supplemented by a citizen survey. The **methodology and analytical framework** also follow [1]. The four Operational Briefs address the same concerns, risks, needs, and gaps identified in the policy analysis. However, whereas [1] focused on regulatory and policy design, this work **shifts attention to operational decision-making within industry-led R&I processes**.

In particular, the four Operational Briefs highlight **societal concerns around 6G**, which—despite the technology's early stage—call for anticipatory reflection. Such concerns signal where industrial practices, governance, and innovation cultures may fall short in **anticipating societal impacts, embedding values, and sustaining long-term trust**. Societal concerns are thus translated into operational risks, exposing gaps in current industrial practices, including governance mechanisms, deployment strategies, standards, and network architectures, framing emerging needs as practical options for industry actors. They ultimately underline a key insight: achieving a **socially accepted and sustainable** 6G requires not only enabling policies but also the **early, systematic integration of societal values** into industrial practices and technological choices.

The ability to meaningfully incorporate values that matter to users and communities into technology development processes represents both a significant challenge and a highly sensitive undertaking. It is connected not only to the capacity to guide the **reinforcement and dissemination of certain values** in society but also to the potential to **maximise social acceptance**. Consistent with [1], **social acceptance and sustainability** are therefore framed not as downstream outcomes of deployment, but as formative dimensions that should **guide design, development, and governance decisions** from the earliest stages of 6G innovation, particularly in low-TRL contexts. In particular, **sustainability** is to be understood as a multidimensional concept integrating environmental, social, and economic dimensions, **closely intertwined with shared societal values**.

The four Operational Briefs are structured around **two interrelated dimensions**.

The first dimension concerns the level of governance, **culture, and practices of research and innovation**. The analysis of this dimension shows how prevailing techno-economic logics, fragmented accountability, and limited reflexivity risk restricting industry's capacity to properly reflect diversity of perspectives, priorities, and needs, and to understand broader societal implications of technologies. This may compromise the capacity to respond to public expectations and to realise a truly holistic approach to sustainability.

This dimension is captured by the Operational Brief: *Values and Impact: the path to Acceptance and Sustainability*.

The second dimension focuses on specific societal values and rights that are particularly exposed in the current trajectory of 6G development, by tracing connections with concrete risks at the level of architectures, deployment models, and value chains.

This dimension is elaborated in the three Operational Briefs: *Safeguarding Privacy in 6G*; *Ensuring Inclusion-by-Design for 6G*; *Securing Europe's Technology Sovereignty in 6G*.

More specifically:

Operational Brief *Values and Impact: the path to Acceptance and Sustainability*

This brief elaborates on the overarching **cultural, governance and methodological** non-technical **conditions** enabling innovation practices that are sustainable under the economic, environmental, and social dimension. It focuses on four main cross-cutting and interrelated dimensions: *values*; *societal impact*; *social acceptance; sustainability*, exposing risks associated with a persistent techno-economic logic; limited anticipatory exploration of impact; a purely formalistic or procedural use of stakeholder engagement, or the reduction of sustainability to narrow environmental metrics. To mitigate these risks, the brief suggests how to interpret, prioritise, and operationalise these dimensions across industrial R&I processes. In particular, it advances the concept of social desirability; emphasises the need for a broader exploration of societal impacts generated by ICTs; it frames social acceptance as an ongoing process rather than a market outcome, and finally calls for a full cultural integration of sustainability, understood not as a constraint but as a value-creating asset.

Recommendations revolve around the following aspects: 1. the need to make social desirability a transformative driver within the technological process; 2. the need for specialised competences to manage the complex relationship between values and technology, so as to meaningfully reflect social values that count in the innovation process; 3. approaches to proactively anticipate, assess, and guide the broader societal impacts of future network technologies; 4. aspects worth to be investigated from an ethical and sociological point of view in the context of immersive communication environments; 5. the need to comprehensively interpret environmental and social sustainability in research and innovation processes; 6. the transition towards sustainability as an integral value and strategic driver within innovation processes.

Operational Brief *Safeguarding Privacy in 6G*

It responds to risks arising from the data-intensive, AI-native, and globally distributed nature of future 6G networks. It translates concerns around loss of user agency, opaque profiling, fragmented accountability, and cross-border data exposure into operational guidance on privacy-by-design, accountability across complex value chains, governance of AI-driven decision-making, and safeguards for international data flows.

It proposes eight main recommendations: 1. Restore user control over 6G data processing; 2. Protect EU data sovereignty from cross-border and foreign access risks; 3. Regulate AI-native profiling and automated decisions; 4. Clarify accountability across complex 6G ecosystems; 5. Reconcile conflicting privacy interests within the value chain; 6. Modernise legal rules for location data; 7. Enforce privacy, data protection and security literacy; 8. Reinforce targeted research and coordinated policy support.

Operational Brief *Ensuring Inclusion-by-Design for 6G*

It addresses risks related to the reproduction or amplification of digital divides through 6G deployment. It focuses on operational measures to support equitable access, affordability, skills development, accessibility-by-design, participatory governance, and outcome-oriented monitoring of social benefits, recognising inclusion as a condition for long-term legitimacy rather than a secondary deployment concern.

It proposes six main recommendations: 1. Guarantee equitable infrastructure access and affordability through coverage planning, transparent reporting, and meaningful social tariffs; 2. Build sustainable local digital-skills ecosystems aligned with the European Digital Competence Framework (DigComp); 3. Implement outcome-focused monitoring and intervention using disaggregated indicators and Key Value Indicators (KVIs); 4. Embed accessibility-by-design across 6G systems and services in compliance with EN 301 549 and emerging standards; 5. Strengthen participatory governance and procedural justice through meaningful community engagement; 6. Contribute to inclusion-focused research and coordinated European efforts.

Operational Brief *Securing Europe's Technology Sovereignty in 6G*

It responds to risks linked to Europe's dependence on external actors for critical technologies, supply chains, and standards-setting processes. Framing sovereignty as open strategic autonomy, the brief provides operational guidance on supply-chain resilience, governance capabilities, coordination in standardisation, protection against foreign interference, and the development of specialised expertise within industry and innovation ecosystems.

It proposes six priority recommendations: 1. Strengthen supply chain resilience through diversification, transparency mechanisms such as Software Bills of Materials (SBOM), and investment in European capacity; 2. Build internal expertise for independent 6G technical assessment, reducing dependence on vendor expertise for critical decisions; 3. Lead in global standards bodies to embed European values in technical specifications through active participation in 3rd Generation Partnership Project (3GPP), O-RAN Alliance, and European Telecommunications Standards Institute (ETSI); 4. Harden systems against foreign government access and interference through zero-trust architectures and supply chain attestation; 5. Align with harmonised European approaches to security, certification, and deployment requirements; 6. Contribute to sovereignty-focused research, certification frameworks, and governance capacity building.

Taken together, the four Operational Briefs converge on a shared conclusion: **the challenge of delivering a socially accepted and sustainable 6G is as much a technical issue as an operational and governance one.** The deliverable clarifies the links between aspects such as **social acceptance, social acceptability, societal impact, and sustainability**, and how these relate to **industry practices and technological decision-making**. It highlights the need for industry actors to rethink how values are embedded in architectures, business models, and innovation practices—expanding reflexivity and participation, while aligning technical performance, economic objectives, and societal priorities. As concerns sustainability, it is presented as a value in itself, against which design choices, trade-offs, and performance metrics should be assessed.

By translating the policy-oriented analysis of [1] into industry-facing operational guidance, this deliverable supports Europe's ambition to develop a next-generation connectivity that is not only technologically advanced, but also ethically grounded, socially legitimate, resilient, and aligned with European values.

Table of Contents

ABBREVIATIONS

Abbreviations about the project structure and deliverables

WP: Work Package.

Dx.x: Deliverable (e.g., D1.1, D1.2).

Abbreviations about technological and methodological concepts

6G: Sixth Generation (of mobile networks).

AI: Artificial Intelligence.

KVI: Key Value Indicator.

Abbreviations about legal and policy frameworks

GDPR: General Data Protection Regulation.

Abbreviations about organisations and processes

R&I: Research and Innovation.

RRI: Responsible Research and Innovation.

SNS JU: Smart Networks and Services Joint Undertaking.

Other Abbreviations

TRL: Technology Readiness Level.

1 Introduction

As 6G technologies evolve towards highly distributed, AI-native, and sensing-intensive infrastructures, decisions taken within research, innovation, and industrial processes increasingly shape not only technical performance, but also societal impact, legitimacy, and long-term sustainability. In this context, societal values such as privacy, inclusion, technological sovereignty, and environmental responsibility are directly affected by the architectural choices, governance arrangements, business models, and deployment strategies adopted by industry stakeholders.

The present deliverable consolidates the main operational insights emerging from the 6G4Society project and translates them into industry-facing guidance. In complementarity with [1], which focused on a policy-oriented analysis, this work focuses on how societal concerns, risks, and expectations can be addressed through concrete operational practices, governance mechanisms, and decision-making processes within complex 6G innovation ecosystems.

The document is structured around four Operational Briefs aimed at supporting industry actors in addressing societal, ethical, and sustainability-related challenges arising in the development and deployment of future 6G networks. By providing actionable operational guidance, this deliverable aims to support industry actors in aligning technological innovation with European societal values, strengthening trust and legitimacy, and contributing to the development of 6G networks that are not only technologically advanced, but also socially acceptable and sustainable. The term "operational" is to be meant, in this deliverable, in a broad sense, referring not only to technical operations, but also to organisational, governance, and decision-structuring practices through which industry actors reflect societal values into concrete innovation, design, and deployment choices.

Each Operational Brief addresses a specific dimension that is critical for ensuring the social acceptability and sustainability of 6G: governance arrangements, with a focus on social desirability and impact anticipatory practices; privacy and fundamental rights; inclusion and equitable access; and technological sovereignty and resilience. While each brief targets a distinct area, they share a common analytical approach and are intended to be read as a coherent set.

The operational options presented in this deliverable are intended to be context-sensitive and adaptable. Their relevance, scope, and level of responsibility vary depending on the role of actors within the 6G value chain (e.g. large vendors, SMEs, infrastructure providers, research organisations, or ecosystem orchestrators). Not all actors are expected to address all dimensions in the same way; rather, the guidance aims to support proportional and role-appropriate integration of societal values across diverse industrial contexts.

1.1 Relation to project work

The activities contributing to the present industry-oriented analysis leverage the findings and contributions emerging from WP1, WP2, and WP3, spanning societal impact trend analysis, public engagement, coordination with 6G-SNS projects and the SNS-JU community, interviews with experts, as well as strategic foresight, towards fulfilling the objectives of project *Task 1.4: Policy and regulatory monitoring, mapping and recommendations*.

The present document is thus based on the analysis on the work carried out within the following project **deliverables, representing the references for the project findings** used in this analysis. All those findings will be further analysed in this document to ultimately ground the formulation of operational recommendations for **industry actors, researchers and technology developers, infrastructure providers, and multi-actor innovation ecosystems** involved in shaping the future of 6G.

- **D1.1** [2]**:** A foundational analysis on three key societal dimensions of 6G technology development: societal impact; driving values; social acceptance. It provides insights on the complex nature of social acceptance in the 6G context and introduces reflections and frameworks (the SAT and the KVIs) to integrate sustainability and social aspects into 6G development from the outset.
- **D1.2** [1]: The Policy Brief paves the way for the operational briefs contained in this document. It provides an extensive summary of the main findings and conclusions of the 6G4Society project.
- **D2.3** [3]: It elaborates on citizens feedback towards public acceptance of 6G technology.
- **D3.2** [4]: It elaborates on how social acceptance of 6G technology is currently conceptualised and operationalised within the EU research and innovation (R&I) community, presenting the main project findings derived by the engagement of SNS JU projects and experts.
- **D3.3** [5]: It elaborates on the SNS JU community work on Key Value Indicators, and proposes a list of Key Sustainability Indicators for 6G Technology.

1.2 Structure of the Document

This deliverable is structured as follows:

Section 1 introduces the **scope and objectives** of the document. After situating the deliverable within the broader 6G4Society project activities, it clarifies the document's industry-facing orientation, and its role in supporting the operationalisation of societal values in the context of 6G development and deployment. It also situates.

Section 2 presents the **methodological approach** underpinning the Operational Briefs. It outlines the value-driven and risk-based framework adopted to translate societal concerns into operational risks, identify gaps in current industrial practices and governance arrangements, and formulate operational options tailored to industry actors.

Section 3 provides an **overview of the four Operational Briefs** summarising the focus and objectives of each of them. The full texts of the Operational Briefs – core of the deliverable – are provided in the annexes.

Annex I contains the Operational Brief on *Values and Impact: the path to Acceptance and Sustainability.*

Annex II contains the Operational Brief on *Safeguarding Privacy in 6G.*

Annex III contains the Operational Brief on *Ensuring Inclusion-by-Design for 6G.*

Annex IV contains the Operational Brief on *Securing Europe's Technological Sovereignty in 6G*.

Section 4 concludes the deliverable by **synthesising cross-cutting insights** emerging from the four Operational Briefs and highlighting their combined contribution to fostering a socially accepted and sustainable 6G.

2 METHODOLOGY

Europe's transition towards 6G requires not only advanced technological capabilities, but also a **systematic operational reorientation of research, innovation, and industrial practices**. As 6G evolves into a hyper-distributed, AI-native and sensing-intensive ecosystem, many of the societal risks identified at the policy level in [1] can be concretely put in place through the architectural choices, governance arrangements, business models, and deployment strategies adopted by industry actors.

This industry-oriented document builds directly on the policy-oriented analysis developed in [1]. While [1] primarily addresses EU policymakers and R&I funding programme designers, the present document – starting from the same analytical framework and addressing the same risks, needs, and gaps – translates the previous work into industry-facing operational guidance. The methodological therefore shift lies therefore not in the nature of the concerns identified, but in the level at which they are addressed: from policy design to operational decision-making within industrial and innovation ecosystems.

The methodology follows a **value-driven** and **risk-based approach**, grounded in the assumption that social acceptance, social acceptability, societal impact, and sustainability are not downstream outcomes of deployment, but formative dimensions that must inform decision-making from the earliest stages of technology development, particularly in low-TRL contexts. In line with [1], societal values are treated not as abstract principles, but as operational reference points against which technological trajectories, trade-offs, and priorities can be assessed.

Operationally, the approach proceeds through **three consecutive steps**.

First, societal concerns identified through the empirical work underpinning [1]—including citizen surveys, participatory workshops, expert interviews, and sustained engagement with the SNS JU ecosystem—are translated into **concrete operational risks** relevant to industry practices. These risks highlight where prevailing techno-economic logics, fragmented accountability, or limited anticipatory governance may undermine trust, legitimacy, and long-term sustainability and well-being.

Second, the analysis identifies **gaps and misalignments** between these risks and current industrial practices, standards, and governance mechanisms. This includes gaps in how values are operationalised in design and architecture, how impacts are anticipated and assessed, how responsibilities are distributed across complex value chains, and how sustainability and inclusion are embedded into business and deployment models.

Third, the identified gaps are translated into **operational options for industry**. These options are intended to support industry actors in embedding societal values into concrete practices, such as architectural design, data governance, supply-chain management, stakeholder engagement, impact assessment, and performance monitoring. Throughout the brief, recommendations are framed as enabling guidance, recognising the diversity of industrial contexts and avoiding one-size-fits-all solutions.

Across all sections, particular attention is paid to the interdependencies between governance choices and technical design. While ensuring conceptual continuity with [1], this methodological approach does not introduce new societal concerns, but operationalises **policy-oriented insights into actionable, context-sensitive operational guidance**, supporting industry stakeholders in aligning innovation practices, technological choices, and deployment strategies with European values, fundamental rights, and sustainability objectives.

3 Operational Briefs Overview

This section briefly illustrates the focus and content of the four Operational Brief. The full elaboration, comprising recommendations and options, is provided instead in the annex sections.

3.1 Values and Impact: the path to Acceptance and Sustainability

This Operational Brief, detailed in **Appendix I**, addresses the governance, cultural, and methodological conditions that shape how societal values, impacts, and sustainability are integrated into 6G research, innovation, and industrial practices. Its final aim is to support industry actors in strengthening governance and anticipatory capabilities, decision-making processes, and in embedding sustainability as a multidimensional and strategic dimension of 6G innovation.

As 6G evolves into a highly distributed, AI-native and sensing-intensive ecosystem, decisions taken at early stages of design and innovation increasingly influence not only technical performance, but also societal impact, legitimacy, and long-term sustainability. In this context, values such as social desirability, trust, inclusion, and environmental responsibility cannot be treated as secondary considerations or downstream outcomes, but must inform decision-making across the entire innovation lifecycle.

The brief examines how prevailing techno-economic logics, fragmented accountability, and limited anticipatory practices may weaken the capacity of industry actors to identify societal needs, anticipate impacts and implications, and align innovation trajectories with broader sustainability objectives. It focuses in particular on how sustainability is often narrowly interpreted, how social impacts are weakly anticipated, and how engagement and measurement tools risk being reduced to compliance-oriented exercises.

However, while the Operational Briefs on Privacy, Inclusion, and Technological Sovereignty translate specific societal priorities into targeted operational guidance for industry actors, the present brief fulfils a distinct and complementary role. It is intentionally positioned as a **framework enabling tool**, addressing the governance, cultural, and methodological conditions that enable such operational measures to be designed, prioritised, and sustained over time.

On this basis, the document provides operational guidance on: how to interpret societal values as decision-relevant drivers, how to broaden the exploration of societal impacts of future network technologies, how to use Key Value Indicators (KVIs) as reflexive instruments rather than static metrics, and how to address trade-offs through co-optimisation approaches rather than zero-sum logics.

3.2 Safeguarding Privacy in 6G

This Operational Brief, detailed in **Appendix II**, analyses the challenge of safeguarding privacy and fundamental rights in the context of future 6G networks, characterised by pervasive data flows, AI-native implementation, hyper-distributed architectures, and integrated sensing and positioning capabilities. By framing privacy as a systemic property of the 6G ecosystem rather than as a compliance add-on, the brief supports industry actors in developing data-intensive, intelligent, and globally interconnected networks that remain trustworthy, resilient, and aligned with European fundamental rights.

As 6G infrastructures evolve, privacy risks are no longer limited to individual data-processing activities, but emerge from the interaction between architectural choices, AI-driven network functions, multi-vendor supply chains, and global data dependencies. Decisions traditionally perceived as purely technical—such as routing strategies, orchestration layers, model selection, or sensing configurations—increasingly have direct implications for user agency, accountability, data sovereignty, and trust.

The brief examines how these interdependent dynamics may undermine privacy if not addressed at an operational level, focusing on risks related to loss of user control, opaque profiling and automated decision-making, fragmented accountability across complex value chains, foreign access to EU data, and the societal implications of large-scale sensing and geolocation. Rather than treating these risks in isolation, the document highlights how they reinforce one another and require coordinated responses across governance, architecture, and organisational practices.

On this basis, the Operational Brief provides industry-facing guidance on how to embed privacy and rights protections directly into 6G design, implementation, and deployment processes. It outlines operational options to strengthen user agency, reinforce data sovereignty, integrate accountability and transparency into AI-native network functions, ensure responsibility across multi-vendor ecosystems, mitigate the societal risks of sensing and positioning, and promote organisational and engineering literacy.

3.3 Ensuring Inclusion-by-Design for 6G

This Operational Brief, developed in **Appendix III**, examines how inclusion can be embedded into the design, deployment, and governance of future 6G networks, recognising inclusive connectivity as a precondition for social legitimacy, democratic participation, and long-term sustainability. Inclusion objectives are then translated into concrete operational practices with the aim of supporting industry actors in developing 6G networks that expand opportunity, reducing structural inequalities, and contributing to a digitally connected society that is fair, cohesive, and socially legitimate.

As digital connectivity increasingly mediates access to essential services such as healthcare, education, work, and civic participation, the deployment of next-generation networks has direct consequences for who can participate fully in social and economic life. With 6G expected to deepen the integration of connectivity into critical infrastructures and everyday environments, existing inequalities related to access, affordability, skills, accessibility, and participation risk being reproduced or amplified if not addressed proactively.

The brief analyses how technical and organisational choices—ranging from coverage planning and pricing models to interface design, skills provision, and governance arrangements—shape inclusion outcomes. It highlights how current approaches often prioritise infrastructure deployment and performance metrics, while paying limited attention to whether connectivity translates into equitable outcomes across different populations and territories.

On this basis, the document provides industry-facing operational guidance to support inclusion-by-design throughout the 6G lifecycle. It addresses how to ensure equitable access and affordability, build sustainable local digital-skills ecosystems, monitor inclusion outcomes using value-oriented indicators, embed accessibility across systems and services, and strengthen participatory governance with affected communities. Rather than treating inclusion as a downstream or compensatory measure, the brief frames it as a guiding criterion that should inform decision-making from the earliest stages of innovation and deployment.

3.4 Securing Europe's Technology Sovereignty in 6G

As developed in **Appendix IV**, this Operational Brief depicts how technological sovereignty can be strengthened in the development and deployment of future 6G networks, focusing on the operational implications of dependency, security, resilience, and value integration across complex digital ecosystems. The aim of this Operational Brief is to support industry actors in developing 6G infrastructures that remain globally interoperable while preserving Europe's capacity to embed its values, maintain security, and ensure long-term resilience in next-generation connectivity.

As 6G evolves into an AI-native, cloud-based and highly software-defined infrastructure, technological sovereignty increasingly depends on a wide range of interconnected decisions related to supply chains, standards participation, architectural design, data governance, and organisational capabilities. In this context, sovereignty is not limited to industrial capacity alone, but encompasses the ability to design, deploy, and govern network infrastructures in ways that preserve security, resilience, democratic accountability, and alignment with European values.

The brief analyses how Europe's reliance on external actors for critical components, software, cloud infrastructure, and standards-setting processes may create vulnerabilities that extend beyond economic competitiveness, affecting security, trust, and the capacity to exercise autonomous decision-making. It highlights how architectural choices—such as cloud-native orchestration, AI-driven optimisation, network disaggregation, and integrated sensing—introduce new sovereignty-relevant risks if not accompanied by appropriate governance and operational safeguards.

On this basis, the document provides industry-facing operational guidance to translate strategic sovereignty objectives into concrete practices. It addresses how to strengthen supply-chain resilience, embed accountability across multi-vendor ecosystems, enhance protection against foreign interference, align security practices across Member States, and contribute effectively to global standards development while maintaining interoperability. Rather than framing sovereignty as technological isolation, the brief adopts an approach centred on resilience, transparency, and open strategic autonomy.

4 CONCLUSIONS

This work starts from the awareness that the challenge of delivering a socially accepted and sustainable 6G is depends on technical choices as well as from operational and governance ones. Against this background, this deliverable **complements the policy-oriented work of 6G4Society**, targeting industry, informing corporate cultures, strategies, practices, and processes. The aim is to provide guidance and clarification on how choices and decisions, also at early stages of technological development, influence outcomes in society, in terms of social values reinforced, social acceptance, societal implications, and sustainability.

In doing so, it supports a more coherent alignment between governance ambitions and industrial practices. It also contributes to Europe's broader ambition to shape next-generation connectivity that is not only technologically advanced and economically viable, but also socially acceptable, sustainable, and aligned with European values and democratic principles.

The work – consisting of four different Operational Briefs – builds on the **founding relevance of the *value* dimension***,* which is addressed at two levels: that of processes and operations enabling the consideration and reflection of values throughout the development process (Brief on *Values and Impact: the path to Acceptance and Sustainability*). Values are also considered as societal priorities themselves, highlighting the circumstances (technical, social, procedural, political) constituting possible threats, and outlining what technical solutions or operational choices would contribute to their strengthening (Briefs on *Safeguarding Privacy in 6G*; *Ensuring Inclusion-by-Design for 6G*; and *Securing Europe's Technological Sovereignty in 6G*).

At a general and overarching level, the four briefs confirm a central insight already emerging from the broader 6G4Society analysis: **the conditions for enabling social acceptance, positive societal impacts, and holistic sustainability are shaped less by technological capabilities alone than by how innovation processes are organised, governed, and enacted in practice**. This means that any issue relating to social acceptance, sustainability, unfair or problematic social impact, as well as risks of insufficiently protecting and covering social values or human rights (e.g. privacy; inclusion) **do not arise in isolation**, **nor manifest suddenly** at the level of roll-out and implementation. Instead, **misalignments between technology orientations and the social context** they are situated in and that they contribute to shaping, emerge from cumulative decisions related to architectures, data governance, business models, supply chains, performance metrics, and engagement practices.

Shortcomings at the level of governance and practices (e.g., prevalence of technology-push and techno-economic logic; procedural and compliance approaches to stakeholder engagement, values, or sustainability; limited anticipatory exploration of broader societal implications) relapses on high-impact strategic choices. Limitations in capturing the diversity of societal perspectives and aspirations would result in a **narrow-scoped vision of possible futures** and into missed opportunities for a more disruptive and inclusive exploration of how human and societal development might evolve. A narrow understanding of social impacts translates into a **limited awareness of the potential negative and unintended social implications** that technologies may generate beyond their intended or sector-specific impacts. This in turn compromises the **understanding of costs and benefits, of pains and gains**; the capacity to identify in due time social values or **rights that are either at risk**, or that require a new recognition and protection. Finally, it compromises the capacity of comprehensively scoping and addressing **social sustainability**.

The analysis also focuses on sustainability, highlighting the way it is approached at the practical level, also in view of its cultural framing. The analysis shows a persistent framing of sustainability as a trade-off, a **constraint**, **burden, or renunciation**. On the one hand, this testifies the persistence of a deeply rooted industrial cultural and value framework still **guided by different if not opposite priorities; on the other hand, this narrative framing** explains why sustainability **has not yet evolved into a core strategic and guiding principle** and still fails to contribute to shaping innovation strategic objectives in a transformative way, informing the design and development of products or business models, and ultimately stimulating a real paradigm shift.

The governance and practice level also influences **specific values or rights.** The three Briefs *Safeguarding Privacy in 6G*; *Ensuring Inclusion-by-Design for 6G*; and *Securing Europe's Technological Sovereignty in 6G* illustrate how governance conditions—or their absence—materialise in specific domains, reinforcing one another through complex interactions across the 6G ecosystem, possibly creating misalignment between the pathways shaping next-generation connectivity and the expectations, priorities or needs at different societal levels. Therefore, the briefs show how privacy erosion, exclusionary outcomes, and dependency-related vulnerabilities often **stem from shared structural and organisational dynamics**.

As concerns *privacy*, establishing meaningful **user agency, human oversight, clear accountability, and transparency** becomes the first operational challenge, in conjunction with appropriate choices in terms of **privacy-by-design** and **data sovereignty**, and taking into account the additional **complexity layer brought by native AI**. In this context, fragmented bilateral agreements are no longer sufficient; the industry requires harmonised contractual frameworks, scenario-based mappings of processing roles, concrete industrial development practices, and certification schemes, contributing to enhancing user control, AI governance and data sovereignty.

Inclusion is elaborated upon in its **multifaceted and multi-level dimensions** and risks comprising: gaps in current connectivity generations, risk being replicated or worsened in 6G deployment; underserving of rural and peripheral territories; need for even affordability provisions; skills gaps persisting among older adults, jobseekers, low-income households; accessibility standards only partially implemented; limited citizen participation in infrastructure decisions.

Finally, the overarching level of *Technological Sovereignty* puts forward six critical **vulnerabilities requiring policy intervention**: supply chain dependencies in critical components, fragmentation of global standards processes, risks of foreign government access to European infrastructure, integration with critical sectors creating cascading failure risks, regulatory fragmentation across Member States, and insufficient European capacity for independent technical assessment.

Taken together, the four Operational Briefs point to a shared conclusion: **embedding societal values into 6G development is not an external ethical add-on, but a prerequisite for long-term trust, legitimacy, and sustainability**. For industry actors, this implies moving beyond technology-push and adoption-centric logics, and towards more anticipatory, reflexive, and value-oriented innovation practices that engage with societal priorities from the outset.

With this endeavour ahead, **multidisciplinarity** stands out as a founding, cross-cutting and enabling resource. Without underestimating the challenges connected to it, the position expressed in this work supports the necessity of exploring different approaches. This would allow **widening, integrating and deepening the understanding of all the points of juncture and mutual influence between technology development and society**, as of the earliest phases of technology development.

APPENDIX I – OPERATIONAL BRIEF ON VALUES AND IMPACT: THE PATH TO ACCEPTANCE AND SUSTAINABILITY

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January 2025

TOWARDS A SOCIALLY ACCEPTED AND SUSTAINABLE 6G

Operational Brief on Values and Impact: the path to Acceptance and Sustainability

1. Highlights

The 6G4Society initiative has focused specifically on investigating the social dimensions of the 6G technology environment. More specifically, 6G4Society examined the way 6G development interacts with societal needs, ethical considerations, and sustainability objectives, addressing the central question of how 6G development can be guided to ensure meaningful social and environmental contributions.

This Operational Brief is built upon, and draws from, the direct and participatory observational experience of 6G4Society within the SNS JU project and expert community. The cultural framework and the consolidated practices where innovation unfolds – including existing economic models, consolidated innovation practices, and governance arrangements – constitute its primary objects of observation and critical analysis.

Its purpose is to clarify what **cultural, governance and methodological conditions** are truly conducive to research and innovation practices that are sustainable under the economic, environmental, and social dimensions. It does so by providing guidance on how driving values, societal impact, social acceptance, and sustainability should be explored, identified, interpreted, and operationalised across research and innovation processes, especially in early-stage and low-TRL 6G development.

In relation to the set of 6G4Society Operational Briefs, this Operational Brief addresses a different and complementary level of action. While the Operational Briefs on Privacy, Inclusion, and Technological Sovereignty translate defined societal priorities into specific technical solutions or operational choices for industry, the present brief **elaborates on the overarching governance and methodological non-technical practices** through which such solutions and choices are conceived and shaped. Doing this, it establishes the conceptual, organisational, and cultural foundations to ensure that any vertical operational measures – such as those we propose on privacy, inclusion, and technological sovereignty – are not applied in isolation or as compliance-driven add-ons, and unfold consistently and in alignment with European policy objectives and with Responsible Research and Innovation principles. In this sense, the present brief functions as an enabling and orientation tool, supporting industry and research actors in embedding societal values into decision-making and design processes, impact exploration and assessment practices, sustainability, and value creation strategies.

Against this backdrop, this Operational Brief elaborates on this central question:

How does a limited integration of social dimensions during innovation narrow the institutional and operational framing of sustainability, and to what extent does this hinder the achievement of a truly holistic sustainability? Risks identified relate to values alignment, awareness about societal implications, and the overall approach to sustainability.

Operational recommendations are proposed around three main topics: Values; Impact; Sustainability. They revolve around the following aspects: 1. the need to make social desirability a transformative driver within the technological process; 2. the need of specialised competences to manage the complex relationship between values and technology, so as to meaningfully reflect social values that count in the innovation process; 3. approaches to proactively anticipate, assess, and guide the broader societal impacts of future network technologies; 4. aspects worth to be investigated from an ethical and sociological point of view in the context of immersive communication environments; 5. the need to comprehensively interpret environmental and social sustainability in research and innovation processes; 6. the transition towards sustainability as an integral value and strategic driver within innovation processes.

2. Context of the Issue

The 5G Infrastructure Association described 6G as "one of the basic foundations of human societies of the future." [6], underscoring the pervasive and profound societal impact 6G is expected to trigger. The magnitude of this transformative potential is matched by significant commitments as to its role and mission in society. As elaborated in both institutional and industrial strategic documents, 6G is envisioned as a transformative technology whose ambition extends beyond technological advancement and performance metrics. 6G is considered for its potential to enable a wide range of critical services across multiple sectors, and in particular, to **enable sustainability**, as it can support major polluting sectors—such as transport, agriculture, and construction—in reducing their environmental footprint.

A major conceptual shift accompanies these goals, represented by the expressed ambition of incorporating value-oriented objectives in the design paradigm as of the onset, representing **intangible yet fundamental human and societal needs**. This evolution is explicitly elaborated in the strategic orientations of the SNS-JU, which positions future smart networks and services in support of European policy priorities, including the Green Deal, and of a sustainable and secure internet [7]. Further, the European Sustainability lighthouse project Sustain-6G concretely collects this commitment [8], with the mission of exploring 6G sustainability in a holistic way across the three environmental, economic, and social pillars. Altogether these developments signal a profound **cultural shift**, conceiving the advancement of next-generation connectivity as inseparable from the responsibility to foster societal well-being, protect fundamental rights, and support long-term planetary health.

It is within the space between the pervasive transformative potential attributed to 6G, and the desire to build a system based on social and ethics values, that the reflections of this brief develop. **Triangulating the concepts of values, impact and sustainability**, 6G4Society has explored and critically interpreted the work conducted within the SNS-JU and 6G-IA ecosystem.

The first issue relates to the dimension of values, to how it influences both high-level strategic orientations and the practice of technology development. Dealing with values is inherently complex because values—whether at the individual, corporate, or institutional level—are often implicit and rarely acknowledged in a deliberate or conscious way. This difficulty translates into **biases and limitations** in how the strategic level and the implementation level reflect social values. The result is that research and innovation (R&I) practices risk projecting a **narrow-scoped vision of possible futures** to be designed and pursued, by overlooking the diversity of societal perspectives and aspirations. This translates into missed opportunities for a more disruptive and inclusive explorations of how human and societal development might evolve.

At the level of **technology implementation**, value related considerations raise significant challenges. Despite innovation actors being increasingly expected to define and manage the value dimension within technology development processes, evidence from 6G4Society confirms that many technical experts still lack the **multidisciplinary expertise** needed to navigate the complex interplay between values and technology, and to recognise how cultural values shape innovation, especially at low TRL levels. This **competence gap**, combined with challenges in identifying and engaging relevant stakeholders early on, results in value-related considerations being **addressed predominantly at later TRL stages**, and in a partial and/or **biased reflection of social values** in the innovation process. The potential for value-based design at the earliest stages of technology development, when flexibility is greatest, is therefore constrained, together with the possibility of truly steering technological development toward ethics, values, and social good considerations in technology design.

The second issue highlighted is in the way **impact** is described and addressed within the current technical R&I culture. What emerged is the tendency to act on the **assumption of a beneficial effect** of technology as concerns its impact on society, with **limited awareness of the potential negative and unintended social implications** that technologies may generate beyond their intended or sector-specific impacts. As a result, a number of social impacts — related to the creation of broader value for society or linked to the transformative impact of the digital world on individuals — are often not sufficiently taken into consideration and reflected in the R&I design or assessment processes. This affects – and compromises – in turn: the definition and calculation of costs and benefits, of pains and gains; the capacity of identifying in due time social values or rights that are either at risk, or that require a new recognition and protection; the breath and scope of KVIs and their capacity to capture longer-term impacts, beyond the project lifetime. Overall, these aspects can compromise the capacity of comprehensively scoping and addressing **all three sustainability dimensions**.

More in particular, immersive communication environment has been recognised as an environment liable of profoundly **reshaping society and human experience, calling for a more responsible, anticipatory, and reflexive approach** to innovation, in line with the European Commission strategy on Web 4.0 and Virtual Worlds (the "metaverse") [9]. Important and specific dimensions have been identified in the context of 6G4Society work, through the lenses of social theory and media studies, highlighting needs and opportunities for further ethical and social research. These dimensions include: the reconfigured relationship between body, space, and environment; the blurred boundaries between reality and imagination in the virtual world; the relationship between physical and virtual social space; the perpetration of stereotypes in the virtual world; the role of mediation in immersive communication environments [2].

The third and last dimension analysed is sustainability – how it is addressed within the industrial R&I culture, as a value and as a set of practices. Overall, sustainability continues to be framed often as a **trade-off**, or as a secondary or external consideration, rather than being integrated as a core priority. It remains frequently associated with notions of **constraint**, **burden, or renunciation**, and is often perceived as standing in **tension** with objectives such as competitiveness, performance, and profitability, as well as with creativity and innovation potential. In most business contexts, sustainability **has not yet evolved into a genuine guiding principle** and still fails to contribute to shaping innovation strategic objectives in a transformative way, informing the design and development of products or business models, and ultimately stimulating a real paradigm shift. This partly derives from sustainability not being widely recognised as a **source of business value in terms of market positioning, reputation**, or product and service offerings. This scenario points to two important aspects: on a practical side, sustainability risks to remains peripheral to industrial research and innovation agendas, core business models, and decision-making processes, resulting in only a **superficial and compliance-oriented** exercise, failing to evolve into a genuine driving force and source of business value. On a cultural side, this scenario embodies a disconnect from the fundamental values that should underpin responsible and future-oriented development, reflecting the **persistence of a deeply rooted cultural and value framework, in which competitiveness, profitability and performance hold a higher place in the value hierarchy**.

Final considerations regard the way in which the concepts of **social and environmental sustainability are interpreted** in the context of R&I innovation agendas and practice. Some nuances and aspects considered constitutive of these concepts are currently not taken into sufficient account and not reflected into R&I processes, for a combination of policy-related and competence-related reasons – notably: a low priority attributed to these topics within programmatic research priorities (work programmes) and **missing specialist competences** to properly interpreting and then addressing some specific aspects. However, a proper understanding of these additional aspects remains relevant, to avoid negative social and environmental rebound effects from the digital transformation. Also, the capacity to devise concrete **co-optimisation** strategies, [10], as a way to guarantee a more **holistic alignment** between technological advancements and broader sustainability objectives, remains a critical challenge within the SNS JU community. Appropriate support mechanisms are needed to support industry in this effort, to avoid treating conflicting variables as competing interests, and to ensure that a performance-oriented culture does not overshadow broader sustainability considerations.

6G4Sociey underscores how any such limitations – on capturing social needs, understanding societal impact, incorporating values in the innovation process – may **relapse on the way sustainability is scoped and enabled**, ultimately **hampering** the possibility to realise **sustainability in a holistic way**. The way forward demands **awareness, openness to challenge assumptions**, and ultimately **dedicated guidance** and capacity-building.

3. Operational Recommendations

3.1. R1 VALUES – Guidance and multidisciplinary cooperation is needed to operationalise values in technology

Values represent enduring priorities that function both as individual guiding principles, and as shared cultural frameworks. They motivate actions, shape attitudes, and define what is deemed desirable or negative in a given group or society.

In the context of research and development, when development teams choose to prioritise certain features of 6G, they are not just making technical choices; they are transferring and reinforcing assumptions about what matters most in society. This is why working with values has to do with taking active steering about the directions and impact of technological development in society, actively orienting societal transformation. Addressing values throughout the innovation process allows to link technological advancements to societal legitimacy and policy objectives; it involves, for example:

- **taking an aware stance on which values promoting and reinforcing into society**: values can act as human-centric framing (or, even better, *planet-centric*), to be used to guide design decisions. They can also be used as “balance needle” to weight trade-offs, assess outcomes and evaluate impacts.
- **being responsive to societal priorities**: values are at the basis of any discussion about desired outcomes and priorities amongst different stakeholders.
- **Identifying in due time social values or rights at risk, or requiring a new recognition and protection**. We can look at values through anticipatory perspectives, trying to anticipate unintended consequences and build public trust in 6G systems.

A first, key competence concerns the ability to work with values and to operationalise them throughout the innovation process, making them operative criteria. In this, social sciences can support practitioners with practical and structured guidance, to facilitate a systematic engagement with values and their integration throughout the technology development and innovation process. This is how a social science perspective on technology can contribute (see also [11] and [12]):

- **Elicitation and identification of the values that are relevant in a given technology context -** values are often abstract, multidimensional, and vary throughout contexts, cultures, different social groups, sectors. It is important to identify with awareness which are the driving principles that (often implicitly and unknowingly) orient strategic or technical decisions and define the wider purpose of a project. Such exploration, therefore, helps to uncover assumptions taken for granted, and the deeper cultural and ethical frameworks guiding technological choices. Also, will allow to choose which values should be reinforced. From these considerations will also depend how conflicting values and balance trade-offs will be managed –since advancing one value may impose costs on another.
- **Exploring stakeholder views, and managing conflicting interests.** Different stakeholders may prioritise different values. Mapping these different perspectives across stakeholders is an integral part of the work on values, to explore the different interests and priorities at stake. This may entail the recognition of conflicting interests among stakeholders, which should be acknowledged and managed. These aspects will be dealt with in more detail in the following recommendation.
- **Mastering the interplay between *Value* and *Values*.** *Values* are the underlying principles that drive and shape choices and decisions; they should not be confused with the concept of *value*, meant as the creation of a positive repercussion at different levels of society, often as a consequence of the achievement of end-goals. While the two concepts are linked, they are operationalised in different ways in innovation processes.
- **Understanding when and how in the innovation process (in which phase, and in which way) values exert an influence.** The short answer is "always". Values influence technology development directions and objectives. Values get to orient strategic choices on what technology to prioritise, influence problem-solving approaches, the choice of what use cases to consider, whose voice to include for consultation, and design and functionality decisions. Also, they shape content development. All these levels produce social impact. A key competence lies, therefore, on the capacity to understand what to include, where and when throughout the specificities of the project context. Understanding how values may be concretely reflected into a technology, service or product, and in different phases of the process, is crucial to choose among different options, and actively steer the development process. For this reason, it is important that values are not operationalised only at the end of the project, but as of the conception phase, to become guiding principles. This is needed to not only reveal hidden biases, to build inclusive impact, and builds the necessary transparency for trust.
- **Integrate values into design and development processes.** This attains to navigating the different ways a value can find relevance and be operationalised throughout the innovation process, as of the earliest stages of technology conception (at low TRL), through the translation into appropriate and specific requirements. The different ways to reflect a value into the innovation process may depend on considerations related to the specific socio-technical context.
- **Identification of meaningful key value indicators (KVIs), and of trajectories and thresholds to assess the presence of those values**. The design of appropriate indicators is essential for identifying impacts at the social or societal level and for assessing the extent to which specific values are supported and reinforced within society. Evidence shows considerable heterogeneity in how values are defined and assessed, leading to difficulties in comparing outcomes across studies. Most importantly, the analysis highlights how methods solely oriented toward achieving predefined targets may be inadequate for capturing and engaging with values. A

different conceptualisation of assessment is needed, more related to outlining a *trajectory* rather than capturing a single finish line; more focused on identifying proxies to demonstrate that a quality exists, rather than establishing a precise quantity. Relevant concepts for this endeavour become, therefore, *thresholds* (the minimum acceptable presence of a value); *momentum indicators* (the speed and scale of a positive change); *diffusion indicators* (the spread of a value to new areas). Also, the focus could shift towards *maturity models* –a totally different way of showing progress. Overall, in this field, the provision of clear rationales, methodological steps, and examples are needed, to help teams navigate different options, and explore different approaches to measurement or assessment, notably less numerical or quantitative.

3.2. R2 VALUES – Whose values? The importance of questioning assumptions in technological innovation paths

In its own mission statement, the SNS JU has set objectives to ensure a human-centric and sustainable internet and to meet public policy and societal requirements alongside technical and market targets (for example in areas like security, energy efficiency, health and inclusion). This commitment, grounded on the awareness that business exerts a profound influence on society in terms of impact generated, entails the capacity to involve and meaningfully integrate external voices to shape innovation agendas and therefore the future of society.

However, despite these valuable intentions, evidence collected through observations show that stakeholder engagement practices are often addressed in ways **that limit their potential to shape the initial design and strategic direction** of activities. In practice innovation paths in the telecom sector appear as the reflection of the interests and values of a narrow set of actors, with stakeholders often consulted at advanced stages of the process, after key technical and business decisions have been made, **expressing only validation purposes**.

In this way, the main substantial and initial drivers in innovation remain **technological feasibility** and **market potential**, or the application of existing technologies. This dynamic potentially introduces biases on which foundational elements (technological or otherwise) are prioritised, and therefore on how the future is framed; for example, the persistence of a paradigm that treats hyperconnectivity as an unquestioned and intrinsic value is automatically reinforced.

For industry innovation pathways and choices may appear clear and unavoidable, as naturally reflecting their prevailing values and priorities. Similarly, society – meant as the beneficiaries and users of innovation – may tend to adapt passively to proposed technological future scenarios, without questioning (especially before negative impacts occur) the existence of alternative possibilities or unexplored options.

Although some technological paths may appear inevitable, however, they can be questioned, and interpreted as the products of specific cultural and historical contexts: each choice or step in the innovation pathway is the result of an implicit cultural framework, underpinned by a series of cultural values, often unrecognised (see also [11]).

To summarise, awareness on the relativity of innovation path is still limited; and low awareness on this translates into limitation as concerns the envisioning of our future.

- **It is key to question *whose values are being prioritised and mobilised.*** In order to reinforce the capacity to steer with awareness which social values are being actually promoted and reinforced in society, or left behind, it is necessary to question whether the value and values projected from industry actually correspond to social needs and priorities, including those of underrepresented or excluded groups. Also, attention should be given to recognise who holds decision-making power around the technology and how those decisions shape its development and deployment.
- **It is essential to break away from the entrenched assumptions that govern current technological innovation paths.** Awareness on the relativity of innovation

path should be reinforced within the innovation culture, broadening and strengthening the capacity of imagining future solutions that are truly tailored to actual societal needs. Research and innovation orientations, technological priorities, use-case prioritisation, and approaches to problem-solving should be shaped around different assumptions, questioning on the one hand the need for certain innovations, and understanding – on the other hand – the orientation and priorities of society. Underlying assumptions are to be examined, discussed, and, where necessary, revised.

3.3. R3 VALUES – Whose values? Making social desirability a disruptive and operative criterion

Robust mechanisms for collecting pluralistic inputs have not yet become an integral part of industrial culture. This **limitation in capturing a fair diversity of perspectives** and visions of what constitutes a desirable future has consequences on two interconnected levels. First, a lack of fairness and transparency in decision-making processes can negatively affect relationships among stakeholders, ultimately **undermining trust**. Second, limited exploration of alternative solutions, social visions, and collective needs tends to result in innovation trajectories that primarily reflect the priorities, values, and perspectives of industrial, technical, and scientific actors, who represent **only a subset of society**.

As a result, strategic decisions guiding technological development remain anchored in the viewpoints of a restricted group of stakeholders. This creates a **bias in the definition of priorities**, with future orientations shaped predominantly by what technology is capable of delivering rather than by what society collectively desires or requires. Such a dynamic reinforces technology-driven and performance-oriented value frameworks, privileging technical rationales (e.g., performance or feasibility) and economic considerations (e.g., profitability) over broader societal concerns.

Most importantly, when the diversity of societal perspectives and communities is not adequately considered, the range of possible futures envisioned through research and innovation processes becomes increasingly narrow. The capacity to explore **alternative or disruptive pathways for human and societal development** is weakened. These alternative pathways could be grounded in different priorities and aspirations—focusing on what is socially desirable or genuinely needed—and could support value-driven outcomes such as human well-being, equity, and sustainability.

Developing technologies that meaningfully address social values therefore requires giving voice, throughout the entire innovation lifecycle, to **values and needs that may fall outside mainstream industrial and innovation cultures**. This includes reflecting such perspectives in how technologies are imagined, funded, and deployed. Ultimately, the goal should be to promote innovation that is guided as much by societal impact as by technological potential, thereby unlocking new avenues for innovation grounded in what society deeply and genuinely needs.

- **Social desirability should become a key driver in defining research priorities and guiding decision-making**. This requires openness to capturing the diversity of needs across society, as well as alternative visions and priorities regarding desired lifestyles and the ways in which human and societal development may evolve or be transformed—including pathways that depart from dominant or taken-for-granted assumptions. It implies the possibility of consciously selecting and prioritizing specific human values and future visions, independently of immediate or technology-driven market opportunities. Achieving this shift calls for a broader cultural change and a redefinition of the role of technology in society, moving beyond a predominantly technology-driven paradigm and recognizing that decisions made at each design phase actively shape future societies.
- **The concept of *need* should be redefined**. It should not be understood only in the context of technology push, where – for the purpose of market success – demand and

perception of *need* in consumers can be induced and stimulated through the introduction of supply, even in absence of a clearly expressed social need. In a social desirability context, exploring needs means understanding the orientation and priorities of society, also independently from immediate or technology-driven market opportunities. This may lead to question the path towards certain innovations.

- **The perspective of who has a legitimate stake in technological innovation should be extended beyond the community of business**, technical and industrial specialists and beyond final users, including those social groups or communities that may be indirectly or negatively impacted – or which perceive themselves as negatively impacted. Only in this way, social desirability and societal values can emerge as fully transformative elements within the prevailing technological paradigm.
- **Public controversies around science and technology provide a valuable entry point into understanding what matters to social groups** that may be affected by technological developments, as well as the underlying values attached to social and environmental contexts beyond purely economic considerations (e.g., landscape preservation, quietness, or unspoiled nature, as highlighted in expert interviews). The analysis of controversies—ranging from public scepticism to more explicit forms of opposition—can help elicit points of tension in how different stakeholders prioritise values, as well as reveal the diverse interpretations and meanings that different social groups attribute to the same value. For this reason, controversial views should be constructively acknowledged and managed rather than dismissed.
- **Formal decision-making tools can support the exploration and management of plural and divergent positions** – such as multi-criteria decision analysis, Delphi techniques, or the analytical hierarchy process. These tools can also complement problem-definition and vision-building approaches by helping to clarify shared goals and challenges.

3.4. R4 VALUES – Whose values? The importance of exploring stakeholders and their values

Stakeholder engagement remains an inherent challenge in research and innovation, as it involves navigating a plurality of variables, including divergent interests, asymmetries of power and knowledge, institutional constraints, and temporal misalignments between innovation processes and societal deliberation. These factors make engagement complex, context-dependent, and difficult to standardise. Nonetheless, the importance of stakeholder engagement is widely recognised.

What remains critical is ensuring that stakeholder engagement is **operationalised in a meaningful way.** It constitutes a core component of responsible and socially robust research and innovation, and a key condition for aligning innovation trajectories with societal values and needs. The central issue, therefore, lies not in whether engagement should be integrated, but in how to **navigate its different phases, formats, and degrees of influence** throughout the R&I process. A number of aspects that are especially important to ensure meaningful stakeholder engagement in the context of 6G will be highlighted:

- **Direct interaction with local communities.** The involvement of local communities in decisions that affect their territories is important, for instance in relation to the placement of infrastructures or the transformation of local environments.
- **Transparent and accessible communication** about risks, uncertainties, and potential impacts is key, allowing stakeholders to form well-grounded opinions rather than being confined to validation roles.
- **Participatory approaches supported by tools such as virtual reality** can facilitate understanding, dialogue, and informed deliberation by making complex technological choices more tangible (e.g., the experience of the Trialsnet project).

- **Broadening the range of stakeholders involved** is equally crucial, as it allows the elicitation of social needs, priorities, underlying values, and potential tensions across different social groups.
- **Co-design with stakeholders**: projects should be incentivised or required to engage co-creation activities with vertical sectors (e.g., disaster responders or rural community groups) to ensure that technology addresses real-world pain points rather than theoretical needs. These activities should not be a one off at the beginning (e.g., requirements elicitation) or at the end (e.g., testing) but ongoing throughout the project in order to influence ongoing decisions.
- **Practices of co-creation and co-design** remain areas with significant untapped potential, calling for further methodological development and the cultivation of specific competences to integrate stakeholder contributions more effectively into R&I processes.
- **The quadruple helix model,** long applied in the context of living labs, and grounded on design thinking methods, could offer a relevant reference framework to effectively support the translation of insights from engagement into alternative development choices. It demonstrates how collaboration among academia, industry, government and civil society can foster more pluralist, inclusive and reflexive innovation processes, grounded in real societal expectations and capable of generating more legitimate and socially responsive outcomes.
- **Meaningful stakeholder engagement cannot be improvised.** It should be understood as an articulated and multi-layered practice, rather than as a single or isolated activity. Also, it cannot be treated as an ancillary or procedural requirement. It requires dedicated competences, including facilitation skills, reflexive capacities, and the ability to translate between technical, social, and normative perspectives.

3.5. R5 VALUES – Which are my key values? Identifying and prioritising Key Values in High-Impact Technological Contexts

The identification and prioritisation of driving Key Values constitutes a crucial first step in the responsible development of technologies with high transformative potential, such as 6G. Translating these principles into actionable guidance for innovation, however, is far from straightforward.

Key values express broad normative objectives on which societies often converge upon, at a high level of abstraction—human rights charters and international declarations. However, their concrete meaning and implications emerge only when values are operationalised within specific geographical, cultural, sectoral, and technological contexts, moving beyond abstract consensus toward a grounded understanding of what sustainability, inclusion, or fairness mean in a particular innovation setting. At this stage, challenges and **frictions frequently arise**. Different social groups and stakeholders may attribute varying interpretations, priorities, or degrees of importance to the same high-level principles, giving rise to debates or controversies.

A robust value-based approach should be guided by **three overarching objectives**: 1) uncovering divergent values where different groups prioritise competing concerns; 2) preventing “ivory tower” solutions that reflect only an industry or expert perspective – and may not resonate with the values and needs of the people they aim to serve; and 3) ensuring transparency regarding whose values are prioritised, and for what reasons.

The following steps can help move values from abstract principles to actionable drivers of innovation, providing a grounded basis for defining technological objectives that are both context-sensitive and socially robust (see also [12]):

- **Reflect on Implicit Assumptions.** The process should begin with a critical reflection on the implicit assumptions and values shaping innovation trajectories and decision-making priorities. This involves questioning whose needs and perspectives are being reflected and translated into innovation processes: are the needs and perspectives of specific user groups, of all affected parties, or primarily of who leads the development process? Who decides what is good for users? Is a given interpretation of a value the right one for a given group/environment in that context? Making these assumptions explicit is a prerequisite for inclusive and responsible innovation.

- **Challenge Assumptions through Stakeholder Engagement.** Early engagement with a broad range of stakeholders allows existing assumptions to be challenged and enriched. This exploration aims to understand diverse user perspectives, identify biases, uncover divergent positions, and consider alternative approaches to addressing societal challenges. Such engagement can disrupt established framings and reveal unexpected priorities or concerns, supporting more informed and balanced decision-making.
- **Balance universal value frameworks with context-specific priorities.** Each specific context, in the pursue of its goal to maintain or improve a given condition, would face different challenges; **values will acquire therefore different relevance and priority**, in light of situational needs, risks, and constraints. Value identification in a given context should rely on a combination of top-down and bottom-up analyses. Inputs should be drawn from multiple levels, including policy priorities at international, European, and national scales; industry strategies and incentives; project-level objectives; sectoral drivers; and the concerns and expectations of affected stakeholders. Such an analysis is essential not only for guiding innovation objectives but also for mitigating risks related to societal harm, lack of adoption, or public resistance.

3.6. R6 VALUES – What a KVI is for and what we want KVI to do

The primary purpose of KVIs is to **shift the focus of evaluation from outputs to outcomes**, from what a project produces (such as a testbed), to the actual change experienced by stakeholders (such as increased connectivity for 10,000 previously unconnected citizens). Most importantly, KVIs should be addressed as a **strategic compass** to **monitor and guide** the design of technology toward a **human- and planet-centric** digital future. KVIs serve as **anticipatory proxies**, providing early signals during the research and innovation phase to predict long-term societal benefits that may only manifest years after a project's completion. More specifically, KVIs should be used to:

- to know if an overlooked area is really being addressed;
- to influence the design and testing process;
- to affect business models and exploitation plans;
- to assess how fit-for-context a technology is;
- to assess if the technology needs to be paired with additional activities on different levels (improved infrastructure, policy, standards, etc.) for it to achieve its intended impact.

What a KVI is not: they are not tools to rationalise the use of existing KPIs. They are not to be measured only after a project is over, acting as validation tools. They are not marketing tools. In all of these cases, there are no decisions being made, other than to confirm and rationalise what was already being done.

For a KVI to be effective, it must be decision-relevant. The following are examples of how KVIs can support specific **decision-making** processes, helping to **course correct** and **change design and paths** (see also [5])**:**

- **Navigating Trade-offs**: They should be able to make tensions explicit, such as the conflict between energy efficiency and hardware costs, helping decision-makers ensure that market viability does not always compromise inclusivity or sustainability.

- **Informing Specific Stakeholders**: Indicators should be designed to support specific actors, such as an engineer making a design change, a policymaker determining funding priorities, or a stakeholder in determining for themselves if the technology is right for them.
- **Strategic Layering**: By layering KVIs across different dimensions, from technical capability to regional system leverage, projects can make informed decisions about where to prioritise efforts for maximum societal benefit.

The work on KVIs should therefore happen the following practices:

- **Stakeholder Co-design**: KVIs must be co-defined with the people who will use or be impacted by the technology. This connects the framework with real-world priorities rather than just top-down policy.
- **Multi-disciplinary Teams**: It is recommended that project teams include social scientists, economists, and environmental scientists to navigate the qualitative complexities of societal values and non-technical data.
- **Harmonisation of Language and Process**: There is a need for a common strategic language and processes across projects to ensure that values like "fairness" or "trust" are interpreted and assessed consistently.
- **Establishing Baselines**: Ideally, projects should establish baseline data describing the social situation they are entering so that subsequent changes can be accurately measured. This does not mean, necessarily, threshold data, but data that establishes the current situation (e.g., how many people in a region are currently not gaining value from SNS services, what structural factors are influencing SNS impacts, etc.).
- **Supporting governing framework**: in order to express at best their capacities, KVIs require a governing framework that explicitly **prioritises social and environmental outcomes alongside financial returns**. Otherwise, the path of least resistance will favour profit-maximizing and technologically novel solutions over those that advance equity or sustainability.

3.7. R7 IMPACT - Widening our understanding of the broader social impact of ICTs

Social impact is, by definition, difficult to explore, particularly within projects that run for only a few years. The way social impact is envisioned and explored, however, is critical. Depending on whether and how risks are adequately identified and considered, technology design can be differently oriented: the greater the capacity for anticipatory exploration of long-term and broader societal implications, the greater the opportunity to reflect critically on current technological choices.

Within the current innovation culture, social impact is often scoped focusing mostly on the direct, predictable, and intended effects of a solution. Second-order effects— the long-term social, cultural, and ethical impacts of technological advancements are only weakly considered and not explored systematically. This is due to the combination of two interrelated tendencies within technical R&I environments: on the one hand the tendency to act on the **assumption of a beneficial effect** of technology in terms of social impact; on the other hand, **limited awareness of potential negative implications** for individuals and society beyond intended impacts.

Capturing long-term, diffuse, or systemic impacts of emerging technologies—those that emerge gradually through evolving behaviours, institutional changes, or shifts in social norms – remains an open challenge. The exploration of broader societal implications and transformations triggered by technologies has so far remained largely confined to academic social science research, with approaches that are often difficult to translate into concrete industrial practices and operational processes. Most importantly, a comprehensive socio-technical impact–modelling framework does not currently exist.

A narrow scoping of societal impact affects and compromises, for example, the capacity of:

- Duly calculating cost and benefits; pains and gains. Depending on what aspects of social impact a project decides to acknowledge a different perception will emerge about the value this project creates in and for society. This would influence the work on needs and goals.
- Duly and comprehensively shaping the understanding of the relevant social sustainability dimension;
- Devising KVIs with sufficient breath and scope to capture longer-term impacts, beyond the project lifetime;
- Timely identifying social values at risk, or the need to recognise new social values, emerging rights, or rights in need of renewed protection.

This tendency becomes particularly critical in the sector of ICTs. ICTs do not exist solely as tangible products: they are platforms, services, and infrastructures that shape behaviours, social practices, and structural dynamics, triggering complex and interrelated dynamics at both human and societal levels. In particular, assessing 6G's potential impact (and implications) at the societal level requires awareness on the complex set of dynamics ignited at the cultural, social and individual levels (cognitive, psychological, identity-related, relational, mental health aspects), including the unintended or negative effects that may accompany smart networks and deeply immersive communication ecosystems.

To adequately address these aspects within the innovation ecosystem, it is essential to integrate competences from the social sciences and humanities (SSH) into the innovation culture and processes of the SNS JU community. Here some suggestions and perspectives:

- **There is a need to strengthen shared awareness** of the broader and deep societal implications of ICTs.
- **A new way of approaching and understanding *impact* should be fostered** in the industrial culture. This should move beyond the immediate scope of applications of technology or performance metrics, combining the study of more immediate and intended social impacts, with a broader understanding of the complex set of dynamics that technology triggers at the human and societal level.
- **Broader and longer term social implications aspects should be considered early in the development process** (not only assessed at the end of the process), to inform orientations and choices, enabling timely adaptive measures wherever relevant or possible. Social impact shall not be treated as a by-product, but as a design driver. This is substantial to align technological progress with societal values and well-being.
- **There are inherent challenges in dealing with longer-term and broader implications of technology**. They could be partially counterbalanced by a more aware work during the research process on the mechanisms through which social aspects, values and ethics can be reflected and operationalised into technology design. This may include reflexive checkpoints throughout the design cycle, including research into the mechanisms where social aspects intersect with technical architecture, and mapping social requirements onto technical specifications/design constraints.
- **A number of anticipatory approaches exist** which can help to capture and explore the broader, systemic, and long-term transformations triggered by technologies, uncovering second-order effects and societal dynamics that conventional methods often overlook. These methods shift the focus from purely technical feasibility and performance toward social desirability, long-term societal relevance, and ethical soundness; also, they help uncovering second-order effects and societal dynamics often overlooked by conventional methods. These comprise Constructive Technology assessment methods; Value-sensitive Design; Foresight exercises, mostly based on scenario building; back casting exercises. In particular, the backcasting approach is the one that operationalises the social desirability conceptual perspective.

- **Tools and methods for the anticipatory exploration of possible broader societal implications of technology should be further explored** in project practices. Anticipatory and ethics-by-design methodologies should be more systematically integrated into technology-oriented R&I activities. While combining diverse approaches and perspectives may initially present challenges, their integration should be pursued through an exploratory and iterative process. Over time, this can strengthen innovation culture and support its evolution in the medium term.
- **It is important to leverage complementary and multidisciplinary knowledge**, competences and methodologies, in particular from the social sciences realm, as perspectives able to situate technology within its social context, and to bring and anticipatory perspective.
- **Key social impact dimensions that warrant reflection and guidance in the context of 6G** include, for instance: the effects of an always-on lifestyle on well-being and quality of life; emerging forms of digital inequality arising from hyperconnectivity or heightened surveillance; the interplay between physical, virtual, and imagined spaces and its implications for social interaction and well-being; and the influence of algorithms on personal autonomy, among others.

3.8. R8 IMPACT - Multidisciplinary expertise is key to operationalise values, explore future implications, and generate positive impact

Despite the complexity of the dimensions of social values, and of social impact and implications, and the fact that they relate rather to social science and humanities competences, industry and innovation actors are increasingly expected to define, identify, manage the value and social impact dimension within technology development processes.

Experience working alongside technical teams has shown that technologists alone cannot easily work with societal value. For example, evidence collected through 6G4Society confirms that many technical experts find it difficult to recognise the way cultural values may influence innovation from its very conception, especially in low TRL levels. This translates into **limitations in the possibility to truly steer technological development** reflecting ethics, values and social good considerations into technology design. Conversely, experience from 6G4Society demonstrates the productive and complementary contribution that social sciences can bring to future network research.

While raising awareness within technical teams about **value-related mechanisms, ethics issues, or social implications** remains essential, it is not sufficient to equip technical teams with the competencies needed to analyse the complex interplay between technology, values, society, and impact. This is because these competencies cannot be easily transferred to or mastered by without a more structured social science background.

A list the **key aspects on which social sciences can provide complementary perspective and possibly guidance**, in order to set the basis for substantial social good:

- **Values**: exploration of stakeholders' values and identification of key values; identifications of key moments where values enter, and can be integrated in, the innovation process, including in low TRL phases; shaping of design requirements.
- **KVIs**: translate values into corresponding and context-specific indicators able to suitably capture the generation of positive value for society, notably in terms of social and sustainability impact.
- **Ethics**: closely connected with values aspects, deals not only with ensuring compliance with regulation, but with the capacity of capturing possible ethical implications of activities, through anticipatory approaches and reflections.
- **Impact**: Social sciences competences have been proved crucial to move beyond perspectives limited to laboratories and user experience or satisfaction, and to engage with the broader dynamics of societal transformation, in particular: scoping the areas

of impact of certain use cases and solutions; elicit the way certain technology features could translate into social impacts and societal implications, capturing nuanced dimensions of the social and environmental impacts of technology; supporting in the assessment of social impacts.

- **Sustainability**: complementing the comprehension of how technology relates to social and environmental sustainability

The answer lies in fostering an R&I culture where the **navigation of qualitative societal complexities** is addressed operationally through **multidisciplinary expertise and approaches** – notably seeing the contribution of social scientists, economists, and ethicists.

Projects in the 6G sector should consider integrating social science expertise in the operationalisation of their activities as of proposal conception. This is because the scale, breadth, and complexity of 6G's societal impacts make it highly likely that significant societal, ethical, and sustainability-related implications will need to be addressed. Technical teams are encouraged to actively recognise and value this multidisciplinary contribution, as it is essential for complementing technical knowledge and enabling a deeper, more informed understanding of societal impacts throughout the innovation process.

Immersive communication environments and gaming applications offer an interesting stage to demonstrate the potentialities of a multidisciplinary approach (see also [2] and [13]). In these contexts, the construction of narratives, representations, and virtual identities directly shapes users' sense of self, social roles, peer interactions, and collective imaginaries. From an acceptability perspective, it is crucial to consider which values—such as autonomy, authenticity, inclusivity, and well-being—should be protected as immersive and XR technologies become central to cultural experiences and daily communication. Key concerns requiring careful reflection include emotional manipulation, bodily surveillance, and user dependency. Insights from SSH disciplines—especially social sciences, cognitive sciences, media studies, and psychology—can provide valuable guidance in addressing these challenges.

3.9. R9 ACCEPTANCE – …or Acceptability?

At the core of reflections on acceptance and sustainability is *acceptability*. While *acceptance* concerns how people perceive and respond to a technology once it enters everyday life, *acceptability* focuses on making a technology socially *acceptable* from the outset. This involves evaluating the technology against legal and ethics framework, social values, and societal expectations. While *social acceptance* unfolds as an evolving and negotiated process once technologies enter everyday use, *acceptability*, by contrast, concerns whether and under what ethical and societal conditions technological pathways should be pursued. As such, acceptability becomes critical at early stages of innovation.

Acceptability, being closely tied to the notion of *values*, is often operationalised through value-based design practices, which allow that relevant societal and ethical considerations are integrated early in the development of technologies and solutions. In this way, acceptability fosters: 1) by design compliance with existing regulations as well as alignment with cultural and social norms considered relevant; 2) reflection on which values—autonomy, authenticity, inclusivity, well-being—could be at risk and should be safeguarded, allowing to actuate adaptive measures as early as possible at the level of technology design. Here some considerations (see also [4]):

- **Focus on acceptability before acceptance**. In the context of emerging technologies and low-TRL research—where specific technical requirements are still being defined—discussions on acceptability are more relevant and influential than those on acceptance. For the same reasons, acceptability is relevant in all reflections around sustainability, whenever approached as a fundamental requirement (or value) to be embedded into technology design.

- **Acceptability explorations should be dealt with as early as possible** in technology and solution design. In this way, values, ethical concerns, and divergent visions can surface in time to shape innovation with awareness.

3.10. R10 ACCEPTANCE – Social acceptance not as a goal, but as an exploration

In the business world, drawing from the traditional technology acceptance models such as TAM or UTAUT, it is frequent the tendency to identifying the exploration of social acceptance with the exploration of user experience, interpreting user satisfaction as an indication of future likelihood of adoption and business viability. This approach exposes three main, interlinked limitations:

- It frames the exploration of acceptance solely around ensuring business viability and market success (acceptance as a goal); this undermines the attention to potential rising ethical issues or to significant social transformations that require careful management and guidance.
- It links acceptance to the role of users, overlooking how other social groups might be impacted by or may respond to the technology.
- It circumscribes acceptance to the context and sector of technology use [14], with limited attention to the wider impact of technology on society.

In this approach, acceptance is treated as a goal to be achieved, often by persuading people of a technology's benefits. This reflects a "**technology push**" model, in which companies create demand rather than respond to genuine societal needs. However, achieving acceptance in this way does not necessarily guarantee that the solution aligns with the values of the society that are expected to be built, meaning it may lack true **acceptability**. Moreover, this approach risks delegitimizing alternative perspectives on innovation priorities and does not ensure that the accepted trajectory represents the most **s**ocially desirable direction for technological development. As a result, important considerations that affect both **social desirability** and **social sustainability** may be overlooked.

6G4Society promotes a broader understanding of acceptance that goes beyond measuring user satisfaction, adoption likelihood, or business viability, and is not limited to persuading people of a technology's benefits. It highlights the importance of expanding the analytical perspective to include dimensions that shape the relationship between technology and society, such as values, ethical principles, potential disruptiveness, and wider social implications. Acceptance is framed as an open-ended process aimed at exploring and understanding what people value, examining social perceptions, and reflecting on whose needs are being addressed and whose may be overlooked. In summary, in relation to acceptance 6G4Society promotes the following (for a more actionable explanation on this topic see [4]):

- **Shift from goal to exploration; from outcome to process.** Social acceptance should not be seen as a goal to achieve but as an ongoing process to explore and critically examine whether the values envisioned by industry align with actual societal needs. This approach does not dismiss business objectives but broadens their perspective in terms of social value creation, enabling a comprehensive elicitation of needs and priorities across diverse social groups.
- **Broaden the scope of investigation beyond the use scenario.** Exploring social acceptance should involve a wider range of stakeholders—not just end users—and consider socio-economic and cultural contexts beyond immediate use scenarios, including the community level, and the market and socio-economic contexts.
- **Deliver actionable insights.** Results of social acceptance explorations should identify gaps between technology-driven objectives and societal priorities, uncover concerns from underrepresented groups, and reveal underlying value tensions that may influence adoption, trust, and social legitimacy.

3.11. R11 ACCEPTANCE – Embrace and constructively manage public controversies as tools to explore social desirability

Public controversies on science and innovation arise whenever different social groups prioritise different values or interests. As such, they represent valuable manifestations of where different social groups provide different interpretations of what is desirable in society and for their future, or of how the same concept (e.g., sustainability) may be filled with different meanings. Therefore, public controversies should not be seen as obstacles, but rather as important and **strategic exploratory tools** to explore and expose this diversity of priorities and values among social groups, industry, and institutions. Such controversies could prompt decision-maker or industry to question the criteria leading the way towards the future being built through nowadays choices. In this way, they would foster socially desirable directions. On this matter the following points are highlighted (see also [4]).

- **Open up to alternative or controversial voices to tune towards social desirability**. Conflicting or divergent voices should be acknowledged, embraced, managed, as they can act as valuable indicators for better accessing and understanding relevant social needs. They can help in:
    - Eliciting possible points of tensions in the way different stakeholders or social groups prioritise values, marking where different interests and priorities may collide or diverge from those of decision-makers (industry or institutions).
    - Clarify different interpretations and meanings that different social groups attribute to a same value.
    - Identify key social groups possibly impacted by technologies, and the underlying values that people attach to their social and environmental context beyond economic considerations (e.g., landscape preservation, quietness, or unspoiled nature – as also noted in an expert interview).
    - Highlighting which values are perceived as neglected or violated, offering important insights into societal priorities.
- **Misinterpretation and misunderstanding of scientific facts should not be dismissed**, even when they lead to controversies. They remain interpretatively relevant, as they can indicate gaps in communication or trust within the stakeholder system. What matters here is not the substantive accuracy of the opinion itself, but what it reveals about relationships, expectations, and trust dynamics among stakeholders.
- **The cause of controversies cannot be reduced to lack of knowledge or information.** There is a widespread assumption within scientific and technical communities that public scepticism or disagreement with science stems primarily from a lack of knowledge or understanding, and that improved information transfer alone would be sufficient to increase public support for science. Such an assumption – known as "deficit model of science communication"– has been widely challenged by extensive research in the field of Science and Technology Studies (STS) [15]. The principal limitation of this position is that of overlooking the role of other forms of knowledge (e.g., cultural or experiential understanding), as well as of values, trust, and context, in shaping attitudes toward science. Critics to the deficit model have eventually highlighted the need to understand science communication beyond a one-way, simple transmission of scientific facts from experts to a passive public; they showed instead that public opinion is more complex than the deficit model suggests and that the model's premise that knowledge directly leads to positive attitudes toward science is flawed [16].
- **Controversies around science and technology expose gaps in the governance process and decision-making mechanism**. If public controversies around a certain innovation surface in public and media spaces, it is most probably because the diversity of public perspectives has not been sufficiently represented in the decisional process, and certain social groups do not feel represented by innovation visions and

expectations. This is why stakeholder engagement should be approached not merely as a project activity, but as a governance and management approach that informs and supports decision-making.

3.12. R12 – SUSTAINABILITY – Ensure a comprehensive and contextual interpretation of environmental and social sustainability in research and innovation processes.

Currently, the way in which the concept of social sustainability and environmental sustainability are interpreted in the context of R&I innovation agendas and practice shows a gap in incorporating nuances and aspects that are instead constitutive of the concepts. The analyses conducted in the context of 6G4Society, in particular, highlight the following aspects as:

As concerns social sustainability: aspects considered relevant to correctly scope the concept, and currently not fully addressed are: mental and physical health and wellbeing; cultural identity and diversity; sense of belonging; feeling of being safe in a community and of being part of the community; intergenerational justice; equity in the way assets, resources and benefits are distributed; autonomy; social cohesion; cultural heritage; freedom, the right to disconnect; landscape preservation; quietness; unspoiled nature.

As concerns environmental sustainability: the concept of environmental sustainability is explored predominantly in terms of energy efficiency. Other important aspects appearing less addressed within the activities of SNS-JU projects, are: greenhouse gas (GHG) emissions, circularity, and electromagnetic field (EMF) exposure, but also circularity, and impact on biodiversity.

Some argue that these aspects are overlooked because they are considered less relevant, linkable, or actionable within the scope of 6G research projects; while this position is highly relevant and worth-exploring, it can also be argued that this perceived lack of relevance may actually stem from: 1) **a lower priority attributed** to these topics in programmatic research priorities (work programmes); 2) **a difficulty in establishing meaningful links** with current R&I priorities, targets and project operations; 3) **missing specialist competences** to properly address these aspects. In all cases, it becomes crucial to make sure that these receive the due attention and are effectively addressed, to avoid potential negative social and environmental rebound effects.

Values such as those listed above may be linkable to, and operationalised in, different aspects of project operations – technical requirements, ethics requirements, objectives, or expected impact – and in different moments. Therefore, it is crucial to build a nuanced understanding of how these different environmental and social sustainability aspects – currently more or less weakly addressed – may relate, more or less directly, to the specific activities and operation areas of SNS JU project community, including in low TRL projects. By way of example, consider the following scenarios: circularity may be operationalised through eco-design principles, through sustainable materials, or adopting modular, scalable, and reconfigurable architectures [10]. Besides this, circularity can be realised also, and most prominently, through circular business models. Landscape and cultural heritage become relevant during the phases of deployment of a telecommunication infrastructure. Cultural identity may be operationalised in choices related to language, or other types of contextualisations. Diversity may be reflected in the way a use case addresses needs of underrepresented social groups.

To summarise:

- **There is a need to explore and verify whether or to which extent the values and aspects less represented can relate to the current context of future network technologies**, under which respects and focus. Concrete examples and contextual explanations are needed to better scope specific meanings and nuances of environmental and social sustainability values in the context of SNS-JU project operations. This would help clarify the connection between these values, projects technical operations, and long-term, systemic social impacts;

these connections would then orient projects towards effectively translating and integrating these aspects into project design.

- **The contribution of specific multidisciplinary competences should be encouraged**. For example, specific competences on GHG, circularity, biodiversity should be required as concerns environmental sustainability, to be able to integrate such aspects holistically within the wider picture. Similarly, the visions and narratives advanced by industry as concerns future social scenarios, or the approaches proposed to address social challenges should be analysed in light of social sciences competences. This would make it possible to highlight ethical or social issues related to specific technological solutions and requirements, requiring attention for their potential wider societal implications. This is valuable also for works at low-TRL or on enabling technologies.

3.13. R13 SUSTAINABILITY – Sustainability as core strategic asset. Overcoming the trade-off logic

Within the SNS-JU community, the willingness has been manifested to overcome a trade-off logic, towards a **co-optimisation approach,** with a case-by-case assessment of the relationship and "blend" between different sustainability pillars, as a way to address sustainability dimensions holistically. This marks a positive, substantial shift of intention, in a more general framework where sustainability remains an operative.

Across the broader global industrial landscape, sustainability has long continued to occupy a **peripheral** position within research and innovation agendas, mostly aimed at managing corporate reputation [17]. Only **recently it has started to be looked at as a strategic asset**—a constitutive element of value creation, market positioning, and long-term competitiveness. However, in most cases, sustainability **has yet to evolve into an inherent and core guiding principle** capable of shaping innovation strategies, transforming core business models, or influencing decision-making processes and product design in a substantive way [18]. While some sectors have begun to move in this direction, such instances remain the exception rather than the rule, with consequent risks for the long-term resilience of social and ecological systems.

More commonly, sustainability is still framed as a **trade-off:** a source of **burden**, **renunciation**, or **constraint**, perceived as being in tension with performance, profitability, and competitiveness. This framing reinforces, and is the consequence of, approaches that address sustainability in a largely **non-substantial** and **compliance-oriented** manner, treating it as a **secondary** or **external** requirement rather than an **integral driver** of innovation.

The persistence of sustainability at the margins of industrial research and innovation agendas calls for a **critical examination of its underlying cultural causes.** Currently, industrial and consumer imaginaries reinforce each other: the priority values of dominant industrial and economic cultures shape social norms, collective imaginaries, and expectations within broader society, while these societal expectations in turn sustain and legitimise prevailing industrial priorities.

Since the value framework underpinning the dominant industrial operation culture is characterised by principles such as, e.g., expectations of perpetual growth, short-term profit maximisation, efficiency also at the expenses of resilience, or consumption-driven expansion, and since these principles are engrained in the business models – that is, in the way the *value* is conveyed towards users and consumers – it is normal that tensions have emerged towards sustainability.

There is a de facto misalignment between the value framework underpinning the dominant industrial operation culture, and the fundamental values necessary for responsible and future-oriented development. The values underpinning sustainability – such as circularity; reuse, refurbishment; frugality –finish to come at odds with the current framework of industrial operations. For example, when considering “frugality”, this conflicts with the dominant competitiveness marketing discourse, that is mostly built on “having more” functionalities. As a result, the way sustainability can generate meaningful value for society—including economic value— remains difficult to define, within the current framework. This highlights the need to **rethink what is considered “*value*” in business**, expanding it to include social, environmental, and long-term considerations. Here some considerations:

- **Position Sustainability as a Core Driver of Competitiveness and Value Creation.** There is growing evidence that a change of paradigm is increasingly necessary for sustainability to be recognised and valorised as a driver of competitiveness and generation of value. Sustainability should be embraced as a strategic asset that drives innovation and strengthens market positioning. Organisations should integrate sustainability as a non-negotiable baseline principle, guiding the conception, design, production, and management of activities, products, and systems. This requires overcoming the prevailing “trade-off” culture, reframing sustainability as an enabler rather than a constraint [19].
- **Embed Sustainability Across Operations and Decision-Making.** Sustainability principles should permeate all phases of the value chain, from early R&I decision-making to end-of-life considerations, ensuring that environmental and social impacts are accounted for systematically rather than treated as externalities.
- **Projects need an agreed process for explicitly identifying and documenting tensions between values, performance, and cost**, to a) ensure sustainability is not always sacrificed for market viability; and b) to ensure transparency in the trade-offs made; and c) to support projects in making the trade-offs in the first place.
- **A cultural reorientation about what *value* is necessary**. Current market and business models often assess “success” through paradigms prioritising growth, accumulation, and possession, which inherently conflict with sustainability values. From this stance, sustainability is addressed in a mitigation-oriented and compensatory stance. Instead, the times are ripe for organisations to embrace sustainability and its core principles. To do this, further work is needed towards valorising and making emerge the **financial value and possibility of economic return** linked to components of the sustainability value framework such as frugality; reuse; non-ownership; reduction; modularity of user experience. The cultural and economic dimensions are closely interconnected; changes at the economic and operational level are inseparable from shifts at the cultural level, with **the underlying value system of the business model** representing the pivotal point of transformation.

3.14. R14 SUSTAINABILITY – Circularity as core and founding aspect of sustainability

Sustainability increasingly needs to be understood through the lens of circularity, which constitutes a **backbone and foundational principle** for sustainability. While certain initiatives—such as focusing on emissions reduction—treat only the symptoms of environmental challenges, circularity addresses the root causes of the triple environmental (crisis–climate change, pollution, biodiversity loss) by lessening both our material use and waste to support a healthy planet [20].

To date, circularity and eco-design principles remain **only minimally adopted** within the SNS JU project community, as does engagement with holistic and systemic environmental strategies, which are essential for tackling long-term challenges such as climate change and resource sustainability. This gap presents significant opportunities for both research and practical action, while also highlighting challenges: it is necessary to assess the extent to which materials, product architectures, or sustainability measures may conflict with critical requirements such as performance or reliability [10].

The second and most important level where circularity can be achieved – more closely related to the level of cultural change – is that of **business modelling. Viable circular business**

models, indeed, would provide the framework in which **environmental and financial objectives can coexist without colliding**, under a unified system of driving values (and realizing deep cultural transformation in the way of living and perceiving the generation of *value*). Differently, trying to implement circular practices along the value chain without rethinking underlying business models entails a high risk of sustainability being deprioritised or "loose out".

Circular business models are underpinned by two core values: **shareability** and **durability** (which together realise the more overarching value of "sufficiency"). These values are most effectively realised in models based on **products-as-a-service**, rather than traditional ownership-based sales. In these models, the business focus shifts from producing more physical goods to maximising the utility and value derived from each product through extended longevity and shared use. In such models, therefore, a single product serves multiple users, reducing material consumption and environmental impact. Simultaneously, producers are incentivised to invest in durable, high-quality solutions, as responsibility for the product's performance and maintenance remains with them. This alignment ensures that the product is designed to last longer, benefiting both sustainability objectives and the business model's economic viability.

- **Circular economy should be seen as an essential and core component of environmental sustainability frameworks**, as it acts on the causes of the environmental crises.
- **Circularity should be integrated by design across all phases of the value-chain** – not be considered as a single phase at the bottom phase of the value chain. For instance, the end-of-life stage of products should be incorporated as early as possible into research and innovation decision-making processes, reflecting a broader respect for resources, ecosystems, and the needs of future generations. This requires a more holistic and systematic analysis and quantification of the impact of circularity-based choices (e.g., at the level of material) impact on other outcomes (e.g., reliability, performance…), in order to outline suitable co-optimisation strategies in the context of circularity by design.
- **Circularity should act as value and driver in the designing of alternative business models.** The exploration of circular business models should be incentivised, as a way to operationalise circularity. In this way, the specific set of values underpinning sustainability and circularity (e.g., sufficiency) will concur in creating also business value. Indeed, this calls for efforts to model the impact of this trajectories and shifts in terms of corporate costs, in the short, medium and longer term.
- **Digital product passport Data Dictionaries**. Telecommunications industry actors should proactively implement Digital Product Passport (DPP)–compliant data structures within OSS/BSS systems, integrating circularity directly into core operational processes. This requires the adoption of standardised data dictionaries capable of tracking component-level provenance, material composition, repairability, and dismantling instructions from the earliest stages of procurement. Embedding such data across the lifecycle enables effective circular resource management and traceability. This approach directly supports compliance with the Critical Raw Materials Act (CRMA) targets and strengthens the industry's capacity to meet sustainability and resilience objectives in a systemic and verifiable manner.

3.15. R15 SUSTAINABILITY AND ACCEPTANCE – Reconfiguring narratives, putting sustainability at the core of the value proposition

The fact that sustainability is still not treated as a strategic asset by the corporate world, emerges in the way sustainability is **narrated**. **Compelling and transformative narratives about sustainable facts or goals remain scarce.** And since through proper narratives it is possible to build positive perceptions of facts, the absence of these narratives further limits the capacity of sustainability to be understood and mobilised as a source of strategic and business value.

Such a position on narratives is not to be understood as supporting reputation, like it has been used for all what concerns greenwashing practices. Instead, it is meant as a way to reconfigure the **construction and perception of overall value offered**. What is argued is that consumer awareness towards sustainability has changed and there is now readiness and space for users and consumers to positively receive different form of offers. In this framework, with sustainability as a **core positioning asset**, the presence of less performant features resulting from sustainability-driven choices would not necessarily assume a negative value, nor would be perceived as *minus*, or a *lack*, because they are counterbalanced by the overarching creation of sustainability value. In the case of systems enabling a modulable quality of user experience (e.g., project EXIGENCE), reducing the quality of definition to improve energy efficiency, the value of the offer will not be associated to a lowest definition quality, but to the capacity of providing the best possible offer while taking care of CO2 consumption.

As long as "success" is assessed through indicators built around a different paradigm (newer, bigger, having more, possessing more), a world based on the values of sustainability risks being perceived as less performant and consequently less competitive. Instead, this changing global readiness around sustainability priorities creates an opportunity to rethink prevailing narratives.

It is important to build new business-consumers relationship based on narratives where foundational aspects of sustainability (e.g., reparability; refurbishment; frugality) are not associated with a sense of renunciation, but become fundamental values within a deeply transformed **narrative around sustainability**. **In this framework, the values underpinning sustainability and circularity** (e.g., reparability; refurbishment; frugality) should find core space and be pushed through in narratives / advertisement / selling strategies, creating a different baseline and formula for what is considered a **comprehensive value offer**. In this formula the "selling" of possible "negative" changes (e.g., loss in terms of performance; lower quality of experience) should not be approached and labelled as a *minus* or a *lack*, but acquire a different meaning–e.g., integrity, opportunity, sensibility. This needs to be **shown, made evident, made available, and narrated** in a positive way.

- **Growing public awareness and societal readiness towards sustainability**, makes it a powerful source of innovation and differentiation, rather than as a constraint.
- **Sustainability is underpinned by a different value system that should be positively reinforced through appropriate narratives**. Concepts such as circularity; reuse, refurbishment; frugality; sufficiency should be decoupled by a narrative of deprivation, and associated with positive narrations. In this way it is possible to entail a shift on how the generation of value is perceived at the market level. It deals with a changed perception of the relationship between economic and environmental sustainability value, and with a different logic through constructing market value – engrained on a more distributed, long-term and holistic logic.
- **Customer acceptance and market adoption dynamics should be further investigated** as concerns the creation of sustainability-centred market value; in particular the impact of choices that lower performances (in terms of traditional metrics) should be explored, and possibly reconsidered in the framework of a different logic in the creation of competitive value.

4. Evidence and analysis

The project's findings at the basis of these policy briefs are based on the analysis of multiple sources and the triangulation of quantitative (surveys), qualitative (interviews and workshops), and desk-research methods. Sources have been analysed through the analytical lens of Responsible Research and Innovation (RRI) and Science and Technology Studies, and comprise scientific literature, participatory workshops, surveys and interviews with R&I

practitioners from SNS JU projects, a citizen survey, consultations with policymakers and experts on topics such as social acceptance, 6G, green ICT, smart cities, and sustainability.

Other key sources to understand approaches and methods applied by industry in matters of social needs, social values, social acceptance and KVIs, have been: a two-round **survey** to explore the SNS-JU projects' community [21]; the direct engagement within the **SNS JU community working groups** (e.g., SNS-JU Sustainability Task Force); the constructive face-to-face exchanges and collaborative work conducted for two **EuCNC** events; the active participation in technology-focused SNS-JU projects. Combined, these sources and methods offer a complementary view across diverse stakeholders of how societal values and needs are currently represented and operationalised in 6G research and innovation. Here a synthesis of the main findings.

The way social and societal impact of ICTs are generally conceived and approached is important to the cause of sustainability. It emerged how the **impact of ICTs** is rarely addressed beyond the description of direct and intended effects of technologies, and is mostly viewed as inherently positive. A particularly interesting context where social implications should be further and more broadly investigated – and with anticipatory approach – is that of **immersive communication.** In this context, the relationship between human, technologies, media and the environment will be subverted, calling for specific reflections. The identification of sensitive ethics and sociological aspects in immersive communication is rooted on interpretative categories and knowledge proper of social theory and media studies, and especially on the notion that communication environments not only determine how contents are produced and conveyed, but they also structure the way audiences perceive and interact with these contents, influencing the relational affordances of society. These aspects are further explained in chapter 3 of 6G4Society D1.1 [2].

A narrow awareness and vision on possible societal implications may undermine the substance of *sustainability* actions – **compromising especially the social sustainability** dimension. This narrow framing of impact reflects a more general issue pertaining the **perspective** used to define innovation outlooks and targets.

The analysis of project documents and the collection of expert views through interviews and direct interactions in EuCNC, confirmed a general framework already well elaborated upon by the RRI theory. Innovation **paths appear still shaped by a narrow set of actors and values**, with limited importance attributed to the point of view of non-specialists in defining the trajectories of future technologies, and ultimately, of the future of humanity. This leads to reproducing a vision of the future that reflects **assumptions, visions and priorities** proper of industrial actors. In this cultural and value context, technology tends to be considered as the solution to most of the problems (**techno-solutionism**), universal connectivity is mostly framed as **inherently beneficial**, and **societal progress** tends to be treated as a by-product of technological advancement. Innovation is frequently associated to technological advancement, with the concept of innovation mostly associated to that of technological advancement. Such a vision of the role of technology in society relapses also in the way **social acceptance** is conceived: acceptance is mostly treated as a goal to be achieved, typically through persuading people of the benefits of technology, and reflecting a traditional "**technology push**" model – where companies create demand rather than respond to real societal needs.

Considering that innovation choices shape the boundaries and affordances of future human civilisation, the dominance of a partial perspective raises concerns about the ability to genuinely **capture the diverse needs of society** and to remain responsive to its evolving needs and values.

Shifting from a more strategic level, to the practical and operational one, the work of 6G4Society across SNS-JU projects, combined with insights collected at EuCNC 2025, highlighted that **values represent a terrain of both ambition and challenges for**

technology projects' practitioners. Teams have shown difficulty in translating the value dimension into practical management (e.g., understanding what constitutes a social value, which values to identify, where to look for them, how to derive them), with some using user experience as a more accessible – though not appropriate – proxy for societal values. Regarding Key Value Indicators (KVIs), most projects reported significant difficulties engaging with this concept, especially in low-TRL, technology-focused environments. More broadly, regardless of the TRL level, **KVIs are still not being used as a guiding tool for design.**

Finally, **insights regarding sustainability** are derived from active contributions to the analytical work conducted within the SNS-JU Sustainability Task Force, complemented by interviews with national and European policymakers. These findings are further enriched by direct and participatory observations gained through involvement in project consortia activities. A key analytical perspective relates to **how the discourse on environmental and social sustainability is framed**.

Environmental sustainability is mostly framed around the **need to mitigate negative effects**, leading to treating the relation between economic and environmental sustainability as a continuous **trade-off**. Social sustainability, instead, is often framed around a **generic positive assumption** that technologies can solve social problems. This, combined with a still low awareness on the societal implications of ICTs, may lead to overlook important nuances and categories of values, relevant to define social sustainability in the context of future networks and connectivity.

5. Sources and Resources

This operational brief synthesises findings from 6G4Society Deliverables D1.1 *Societal aspects in 6G Technology: concerns, acceptance models and sustainability indicators* [2] and D1.2 *Towards a socially accepted and sustainable 6G - Policy Brief* [1].

In addition, this work draws from the following project outputs: D3.2, *Social Acceptance of 6G Technology* [4]; D3.3 *Key Sustainability Indicators for 6G Technology* [5]; 6G4Society SNS Survey Report 2024–2025 [21]; 6G4Society Insight Report #1 [11]; 6G4Society Insight Report #2 [12].

6. Contact details

For further information, contact CyberSocial Lab. at eu-projects@cybersoclab.com or visit www.6g4society.eu. Project deliverables are publicly available through the 6G4Society Zenodo repository at https://zenodo.org/communities/6g4society.

APPENDIX II – OPERATIONAL BRIEF ON SAFEGUARDING PRIVACY IN 6G

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December 2025

TOWARDS A SOCIALLY ACCEPTED AND SUSTAINABLE 6G

Operational Brief on Safeguarding Privacy in 6G

1. Highlights

The transition to sixth-generation (6G) mobile network marks a profound shift in the technological and societal landscape, one that goes far beyond a simple escalation in the amount of data being generated.

As highlighted in the 6G4Society policy analysis, 6G introduces **structural transformations in how data circulates, how responsibilities are distributed, how surveillance capabilities intertwine with questions of digital autonomy and how user tracking, identification, and behavioural inference are impacted by 6G intrinsic capabilities**.

Understanding these transformations as a network of interdependent dynamics is essential for translating 6G4Society policy recommendations into actionable guidance for industry. At the foundation of these transformations lie the 6G landscape characterised by **hyper-distributed architectures**, **AI-native functionality**, and **pervasive sensing capabilities**.

Evidence gathered through citizen surveys, expert and policy makers interviews, and Smart Networks and Services Joint Undertaking (SNS JU) project analysis points to five priority risks: erosion of user agency, foreign access to EU data, discriminatory or opaque AI decisions, unclear responsibility across multi-vendor networks, structural tensions among stakeholders with diverging privacy interests, sensing and geolocalisation, privacy and security. These risks are not independent but mutually reinforcing: loss of user agency amplifies sensing-related intrusiveness; foreign access risks intensify accountability gaps; and opaque AI decisions compound existing asymmetries of power across the value chain.

These insights underscore that the success of 6G will depend not only on technological progress but on embedding European values such as privacy, fairness, accountability, and sovereignty into its governance and design.

Against this backdrop, this operational brief examines the central question: ***How can Europe safeguard privacy and fundamental rights as 6G networks become more data-intensive, AI-native, decentralised, and reliant on global supply chains?*** It proposes six main recommendations: 1. Integrate operational mechanisms strengthen user agency; 2. Reinforce EU data sovereignty vs foreign access to EU data and supply-chain exposure; 3. Embed accountability, oversight and transparency into AI-native network functions; 4. Ensure accountability across multi-vendor 6G Ecosystems; 5. Mitigate the societal risks of 6G Sensing and Positioning; 6. Promote organisational and engineering literacy through unified technical guidelines.

2. Context of the Issue

The 6G environment will be characterised by continuous, often invisible streams of **environmental, behavioural, and positional data** produced by billions of devices. Such pervasive sensing challenges governance models that can't rely on explicit consent, user awareness, and clearly identifiable data controllers. In highly automated and ambient network environments, consent risks becoming episodic, symbolic, or detached from real data practices, requiring complementary operational safeguards beyond individual choice alone. In this context, restoring meaningful **user agency** becomes the first operational challenge:

industries developing 6G technologies should design operational tools that are intended to allow individuals to understand and influence how their data is processed, even when the underlying systems are complex, dynamic, and automated.

User control, however, cannot be considered separately from broader structural issues such as **privacy-by-design** and **data sovereignty**. The call for personal data spaces and interoperable tools requires industry stakeholders (such as for instance device manufacturers, cloud and edge providers, and network operators) to **embed granular consent management and transparent data practices** directly into their products and services. At the same time, data sovereignty is not merely a political principle but a concrete operational constraint: making decisions such as for instance **routing choices, data-localisation strategies, and vendor selection** are all directly shaped by the need to protect European data from foreign access regimes and ensure legal certainty. Building user agency therefore depends on industry's ability to align technical infrastructures, governance models, and supply-chain decisions with European principles of autonomy and accountability. In operational terms, this implies that architectural decisions traditionally framed as purely technical (e.g., routing logic, orchestration layers, data replication strategies) become de facto privacy and rights-impacting choices that must be documented, justified, and auditable.

AI-driven network intelligence adds another layer of interdependence to the picture. As 6G networks rely increasingly on autonomous optimisation, behavioural analytics, and real-time decision-making, **profiling and automated decisions** become central to the functioning of the system. This creates direct implications for fairness, explainability, and individual rights. Industry should adopt **AI models that can be documented, audited, and scrutinised**; prevent **sensitive inferences** by design; and ensure that **human oversight** remains possible for critical functions such as for instance resource allocation, intelligent handovers, and edge orchestration. In addition, **clear, enforceable accountability across the multi-vendor ecosystems** that characterise 6G infrastructure should be granted.

This is strictly connected to the necessity of **supply-chain transparency, contractual clarity, and role definition**. As 6G distributes its processing chain across numerous actors handling different segments of the same data flow, there might be the high risk that **responsibility gaps** grow. Fragmented bilateral agreements are no longer sufficient; the industry requires **harmonised contractual frameworks, scenario-based mappings of processing roles, and certification schemes** that make **accountability** visible and verifiable, contributing to enhancing user control, AI governance and data sovereignty. These practices anticipate and operationalise emerging European AI governance requirements by embedding transparency, traceability, and human oversight directly into network functions rather than treating them as ex-post compliance obligations. Without such mechanisms, accountability risks remaining theoretical, undermining both regulatory compliance and public trust in complex multi-vendor environments.

All these measures are inseparable from the broader governance landscape: without **user agency**, sensing becomes uncontrollable; without **data sovereignty**, it becomes vulnerable to foreign exploitation; without **supply-chain accountability**, sensing becomes opaque.

The complexity of the value chain also creates deeper structural tensions. As highlighted in the policy analysis, **privacy, commercial interests, and national security do not simply coexist**. In some cases, they even collide. Operators wish to monetise data for analytics and new services; companies that deliver digital services over the internet depend on granular data for personalisation and targeted advertising [22]; governments demand access for security and law enforcement. The industry should be prepared to navigate these competing pressures by designing **privacy-respecting monetisation models**, implementing **independent audit** and **logging functions**, and building architectures capable of **supporting proportionate, accountable interventions by public authorities**.

Integrated Sensing and Communication (ISAC) exemplifies this interdependence. Unlike previous generations, 6G will incorporate **ultra-precise positioning and ambient sensing** into the very foundations of the network. These capabilities carry profound societal implications, enabling forms of **continuous tracking, identification without interaction, and high-resolution behavioural inference** [23]. Unlike previous generations, these inferences may occur without any explicit user action or service interaction, further challenging traditional notice-and-consent models. Interface-based transparency mechanisms implicitly assume an active user engaging with a service and fail to protect the passive bystander—individuals moving through sensed environments with no application, interface, or practical means to signal refusal. To address this gap, industry should support the development of protocol-level signalling mechanisms, through standardisation bodies such as 3GPP and ETSI, enabling **personal devices to broadcast a standardised "Do Not Sense" flag** that ISAC-enabled infrastructure would be required to recognise and enforce through automatic blinding or masking of sensing data. Industry should therefore adopt **adaptive sensing modes,** enforce **technical limits on granularity,** and select **partners capable of implementing data minimisation-by-design principles**.

Underlying all of this is the need for **organisational literacy**. Meaningful progress depends on ensuring that everyone involved in designing, implementing, and deploying 6G systems shares a clear understanding of the **distinct roles and implications of privacy, data protection, and security**. Building a culture grounded in responsibility, minimisation, and transparency, and **equipping engineers and developers with interdisciplinary skills**, is essential.

Equally crucial is promoting a cultural transformation, **communicating clearly with citizens** about how 6G technologies work, what data they process, and how individuals can exercise their rights.

Finally, research, innovation, and standardisation should close the loop **adopting a value-driven architecture** to avoid bias, control intrusiveness, and ensure accountability. Research and innovation should be guided by **codes of conduct and technical standards** that can be applied directly in real-world systems.

In conclusion, user control, AI governance, data sovereignty, supply-chain accountability, sensing and geolocation safeguards, business-model design, organisational literacy, culture transformation, and value-oriented research should be understood as components of one integrated ecosystem. In this context, the 6G4Society Policy Brief provides the normative and strategic foundations; the Operational Brief translates them into **concrete industrial development practices** aiming at supporting the 6G sector to evolve in accordance with European values and individual's fundamental rights, trustworthy, resilient, and socially legitimate 6G infrastructure.

3. Operational Recommendations

3.1. R1 – Integrate operational mechanisms to strengthen user agency

The pervasive and often invisible data flows inherent to 6G networks risk leaving individuals without a clear understanding of who processes their data and how, making user agency increasingly difficult to exercise in practice. To ensure that 6G technologies uphold user autonomy, transparency and trust, industry actors must embed operational mechanisms that make data practices intelligible, manageable and enforceable. This includes enabling personal data spaces for telecom and sensing data, ensuring **clear identification of data controllers**, and providing straightforward ways for individuals to **exercise their data-protection rights**. These measures allow individuals to meaningfully control their 6G-related data and understand the functioning of pervasive sensing, AI-native optimisation and distributed network architectures.

Operational options are:

- **Establish an EU-wide 6G Personal Data Space**, with standardised APIs allowing users to view, aggregate and modify permissions for all telecom-derived and sensing-related data.

- **Introduce mandatory digital and physical data-controller labels** for 6G and IoT devices, using a harmonised identifier that links directly to simplified rights-request and opt-out mechanisms.
- **Require operators to integrate clear user-facing information modules** into apps and portals, explaining what 6G data is collected and providing accessible controls for access, deletion, restriction of processing and other data-subject rights.
- Ensure that **usage and effectiveness** of these tools (e.g., access requests submitted, permissions modified, opt-outs exercised) are monitored as operational indicators of user agency.

3.2. R2 – Reinforce EU data sovereignty vs foreign access to EU data and supply-chain exposure

As 6G infrastructures rely on globally distributed supply chains and cross-border data flows, European data becomes increasingly exposed to foreign jurisdictions and interference risks, challenging the EU's ability to safeguard autonomy and legal protections. To uphold European data sovereignty in 6G, industry must implement technical and organisational measures that **ensure EU data remains protected from foreign access regimes, high-risk supply-chain dependencies, and uncontrolled cross-border flows**. This requires operational choices in routing, vendor selection, architecture design and data-handling methods that align day-to-day engineering practice with strategic autonomy and privacy protections.

Operational options are:

- Adopt **sovereignty-aware routing and orchestration algorithms** that prioritise EU-based paths and edge resources by default, automatically avoiding data transit through third-country jurisdictions unless technically unavoidable.
- Integrate **vendor-risk scoring** into network design tools, ensuring that components from high-risk suppliers are excluded from data-rich or security-critical segments (e.g., sensing modules, AI orchestration layers, subscriber databases).
- Implement **local-processing and EU-only storage defaults**, using edge nodes, micro-data centres and trusted EU cloud services to ensure that raw sensing data, identifiers and inference-related metadata do not leave EU territory.
- Apply **strong encryption, key-splitting and hardware-root-of-trust mechanisms** so that, when cross-border transfers are unavoidable, foreign jurisdictions cannot access decipherable data or inference profiles.
- Create **auditable data-flow maps for all 6G services**, documenting where data travels, which vendors process it, and which jurisdictions are involved—allowing operators to demonstrate sovereignty compliance and rapidly remediate unwanted foreign exposure.

3.3. R3 – Embed accountability, oversight and transparency into AI-native network functions

As 6G shifts towards autonomous optimisation, behavioural analytics and real-time AI-driven network decisions, the risk of unfair treatment, opaque inferences, and loss of human control increases. To enhance the **trustworthiness** of AI models, maintain system legitimacy and, at the same time, protect individual rights, industry must embed accountability, oversight and transparency directly into AI-native network functions. This requires models that can be documented and audited, mechanisms that prevent sensitive inferences, and operational safeguards ensuring that meaningful human intervention remains possible when network decisions have significant or irreversible effects.

Operational options are:

- Develop **auditable AI models and decision pipelines** by maintaining structured model documentation, versioning, input/output tracing, and explainability metadata for all optimisation, handover, orchestration and analytics functions. Couple these mechanisms with secure logging and retention policies enabling ex-post investigation of contested or harmful decisions by regulators or oversight bodies.

- Implement inference-prevention modules that **automatically block or degrade the accuracy of AI models** when they risk producing sensitive behavioural inferences (e.g., health patterns, political tendencies, social relationships) from telecom data.
- Introduce **architectural human-oversight mechanisms** for high-impact operations—such as mobility prediction, edge orchestration or prioritisation decisions—through the use of deterministic safety monitors and sandboxing patterns. Rather than relying on real-time human intervention, which is infeasible in sub-millisecond 6G environments, AI components should be wrapped by **non-AI control layers that enforce pre-defined safety, policy and performance bounds defined by human operators** responsible for system design. When AI outputs fall outside these bounds, the system should automatically block the action and revert to a validated safe baseline. This approach operationalises the **human oversight requirement under Article 14 of the EU AI Act through oversight-by-design**, rather than active intervention, which represents the only viable implementation path for real-time 6G network functions.
- Adopt **privacy-preserving learning and distributed analytics techniques**, such as federated learning or edge-constrained training, to avoid centralising raw behavioural data while still enabling performant AI-native network intelligence, thereby reducing systemic risks while preserving the autonomy and responsiveness required by AI-native 6G networks.

3.4. R4 – Ensure accountability across multi-vendor 6G Ecosystems

Responsibility gaps in multi-vendor 6G environments undermine societal values such as accountability and justice. To ensure meaningful redress and clear traceability across complex supply chains, accountability must be engineered directly into network architecture and operational workflows. Technology should make responsibility **transparent, auditable and enforceable** across all vendors, components and processing stages.

Operational options are:

- Deploy **cryptographic provenance** systems that record which vendor processed which data, at which stage, and using which model or algorithmic component.
- Adopt **transparent chain-of-responsibility registries**, providing regulators and supervisory authorities with verifiable mappings of actors, roles and data-processing responsibilities.
- Synchronise **fault-tracking and incident-response** APIs across vendors, ensuring coordinated accountability, rapid remediation and consistent escalation procedures in multi-actor infrastructures.

3.5. R5 – Mitigate the societal risks of 6G Sensing and Positioning

The societal implications of ISAC (such as continuous tracking, object detection and behavioural inference) combined with the largely invisible nature of sensing, require that **transparency, proportionality and minimisation, purpose limitation and accountability** be engineered directly into 6G infrastructures. The ultra-precise positioning and ambient sensing capabilities of 6G significantly increase the intrusiveness and sensitivity of location data, making traditional safeguards insufficient.

Operational options are:

- **Transparency: Provide network-level transparency feeds** disclosing which sensing modes, inferences or automated actions are active in specific contexts. **Equip devices with local transparency agents** summarising the categories of data processed by nearby 6G nodes. **Standardise machine-readable transparency descriptors** allowing third-party apps to generate simple, citizen-oriented explanations of sensing activities.

- **Proportionality and minimisation: Introduce adaptive sensing and precision-reduction mechanisms** that automatically lower spatial resolution when high accuracy is not technically required. **Apply minimisation-by-architecture**, ensuring raw, high-resolution environmental or location data is processed locally, with only abstracted or anonymised results shared across the network. **Architect edge-first processing pipelines**, keeping raw location and sensing data at the device or local edge node, with only aggregated or anonymised positioning information propagated to the wider network. **Support protocol-level opt-out mechanisms, such as a standardised "Do Not Sense" signal broadcast by personal devices**, requiring ISAC-enabled infrastructure to exclude the corresponding physical target from high-resolution sensing, storage and inference pipelines, except where strictly necessary for immediate system operation.
- **Purpose limitation: Implement context-aware sensing policies**, reducing environmental scanning or positioning precision near sensitive locations or during low-risk operations. **Tag all location data streams with machine-readable purpose and retention metadata**, enabling automated enforcement of necessity, proportionality and consent requirements across services and vendors.
- **Accountability and No Repudiation: Deploy tamper-evident access-logging systems** capturing requester identity, purpose, timestamp and authorisation for all fine-grained location queries. **Use strict role-based access controls (RBAC)** within network management and analytics platforms to ensure only authorised personnel or processes can access high-precision location information, and enabling **auditability of the enforcement of opt-out and minimisation signals** at infrastructure level.

3.6. R6 – Promote organisational and engineering literacy through unified technical guidelines

The complexity of 6G infrastructures—marked by pervasive sensing, AI-native optimisation and deeply distributed supply chains—requires a level of organisational literacy and multidisciplinary collaboration that goes beyond traditional telecom engineering. Without a shared understanding of how privacy, data protection and security should be interpreted and operationalised, inconsistencies emerge that undermine both user trust and regulatory compliance. To ensure that 6G technologies evolve in line with European values and fundamental rights, industry should **not only adopt common technical countermeasures** (e.g., Blockchain, Quantum Computing, explainable AI, Quantum Key Distribution, Post-Quantum Technology, etc.) **and Privacy Enhancing Technologies** (e.g., data anonymisation, pseudonymisation, zero-trust architectures, differential privacy, etc.). Although they are valid measures, they are not sufficient. Organisations should also cultivate interdisciplinary teams that integrate legal, ethical and engineering expertise, and embed Key Value Indicators (KVIs) into development processes so that societal impacts such as privacy, fairness and accountability are systematically measured and acted upon.

Operational options are:

- Draft SNS JU engineering **guidelines that define shared best practices** for secure, privacy-preserving, accountable and sovereignty-aware 6G design, implementation and deployment.
- Integrate **KVI-based tools** into development and deployment pipelines, supporting organisations on identifying users desires and privacy-related societal values impacting the 6G technology especially in case of vertical use cases, enabling organisations to continuously track how design choices impact those societal values, and to adjust architectures proactively when risks increase.
- Run structured **cross-disciplinary training modules**, bringing together telecom engineers, AI specialists, data-protection lawyers, ethicists and social scientists to ensure that technical teams understand and can operationalise legal, ethical and societal requirements in 6G architectures.

- Establish **multidisciplinary design reviews** as a mandatory stage of the product development lifecycle, ensuring that privacy-by-design, minimisation, explainability, and accountability considerations are assessed jointly by technical, legal and ethical experts before deployment.

4. Evidence and analysis

The project's findings are based on a triangulation of quantitative (surveys), qualitative (interviews and workshops), and desk-research methods, ensuring robustness and alignment between citizen, expert, and institutional viewpoints. Survey responses reflect the perceptions of participants rather than the full EU population, while evidence from SNS JU projects represents early-stage research rather than deployed infrastructures. Nevertheless, the extensive combination of scientific literature, citizen surveys, participatory workshops, interviews with industry practitioners and experts in acceptance, 6G, green ICT, smart cities and sustainability, as well as consultations with policymakers and engagement within the SNS JU community, provides complementary academic, civic, and institutional perspectives on how societal values are currently represented and operationalised in 6G research and innovation, and where alignment with EU frameworks such as the GDPR and the AI Act may require further action.

Across these activities, **privacy consistently emerged as the value most at risk** in the 6G context. Survey data indicate that 47% of citizens view privacy and data protection as their top concern for future connectivity, highlighting anxieties about **pervasive sensing, surveillance, and opaque uses of personal data**. Workshop participants echoed these concerns, emphasising the need for transparency, meaningful consent, and limits on AI-native decision-making. SNS JU projects further substantiated these trends, with over 70% identifying privacy as a priority, particularly in relation to **sensing technologies, data ownership, and the use of network data for AI training**. Expert interviews confirmed a broader shift from traditional privacy concerns to deeper anxieties about **surveillance architectures, algorithmic control, and the erosion of digital autonomy**. These findings closely correspond to the **priority risks** outlined above.

5. Sources

This operational brief synthesises findings from 6G4Society Deliverables D1.1 [2] and D1.2 [1], as well as WP2 and WP3 outputs on stakeholder engagement and liaison with the SNS JU community. It draws on EU legal frameworks including GDPR, ePrivacy, Data Act, AI Act, Cyber Resilience Act, European Electronic Communications Code (EECC), as well as EU policies, strategies, guidelines and recommendations including Digital Decade 2030 (by DG CNECT), Cybersecurity of 5G networks (by EC), WP29 and EDPB guidelines and opinions, EU Toolbox for 5G Security and other ENISA reports.

6. Contact details

For further information, contact CyberSocial Lab. at eu-projects@cybersoclab.com or visit www.6g4society.eu. Project deliverables are publicly available through the 6G4Society Zenodo repository at https://zenodo.org/communities/6g4society.

APPENDIX III – OPERATIONAL BRIEF ON INCLUSION-BY-DESIGN FOR 6G

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December 2025

TOWARDS A SOCIALLY ACCEPTED AND SUSTAINABLE 6G

Operational Brief on Inclusion-by-Design for 6G

1. Highlights

Inclusion is a core European value and precondition for the legitimacy of sixth-generation (6G) mobile network deployment. As digital connectivity increasingly mediates healthcare, education, work, and civic participation, access and use now determine who can exercise democratic rights and access essential services. 6G's deeper integration with critical infrastructure will amplify these dynamics unless inclusion is embedded from the outset. Findings from the 6G4Society project show 45 percent of surveyed citizens identified inclusion and access as top priorities for future digital development, linking connectivity to social justice and quality of life [3]. Without proactive measures, next-generation networks risk reproducing and amplifying current patterns of exclusion, concentrating opportunity among already advantaged populations while deepening the marginalisation of vulnerable groups.

Project findings confirm that persistent gaps in current connectivity generations threaten to be replicated or worsened in 6G deployment. Rural and peripheral territories remain underserved, affordability provisions are uneven, and skills gaps persist among older adults, jobseekers, low-income households. Accessibility standards are only partially implemented, while citizens reported limited participation in infrastructure decisions. Evidence gathered through citizen surveys, expert interviews, and Smart Networks and Services Joint Undertaking (SNS JU) project analysis reveals that inclusion remains a widely articulated public expectation but an underdeveloped dimension of current research and deployment practice [3] [4] [5]. These insights underscore that the success of 6G will depend not only on technical performance but on embedding European values such as fairness, cohesion, and democratic legitimacy into its governance and design [11].

This operational brief examines: ***How can Europe ensure that 6G deployment serves all citizens rather than reproducing existing patterns of digital exclusion?*** It proposes six main recommendations: 1. Guarantee equitable infrastructure access and affordability through coverage planning, transparent reporting, and meaningful social tariffs; 2. Build sustainable local digital-skills ecosystems aligned with the European Digital Competence Framework (DigComp) [24]; 3. Implement outcome-focused monitoring and intervention using disaggregated indicators and Key Value Indicators (KVIs); 4. Embed accessibility-by-design across 6G systems and services in compliance with EN 301 549 [25] and emerging standards; 5. Strengthen participatory governance and procedural justice through meaningful community engagement; 6. Contribute to inclusion-focused research and coordinated European efforts.

2. Context of the Issue

As Europe prepares for 6G, inclusion has become a strategic test of fairness and cohesion. Connectivity is no longer a purely technical or commercial matter but the infrastructure through which individuals participate in modern life. In this context, exclusion from high-quality networks increasingly means exclusion from essential services and democratic processes.

European policy frameworks already acknowledge these challenges. The **Digital Decade Policy Programme** [26] sets binding targets for gigabit connectivity and digital skills by 2030; the **Gigabit Infrastructure Act** accelerates deployment [27]; the **European Electronic**

Communications Code provides for universal service and affordability [28]; and the **Digital Education Action Plan**, the **European Accessibility Act**, and the **Web Accessibility Directive** outline pathways for skills and accessibility [29] [30]. Yet implementation remains uneven. Rural regions continue to experience coverage and quality deficits, affordability mechanisms such as social tariffs vary widely [31], skills initiatives are fragmented. Current accessibility provisions address existing technologies; as 6G introduces new interaction modalities, these standards will need to evolve accordingly. Monitoring remains focused on infrastructure deployment rather than on whether connectivity produces tangible benefits for all populations.

The technical architecture of 6G introduces specific inclusion challenges that industry must address. AI-native network management will require higher digital literacy from users interacting with intelligent, adaptive services. Extended reality (XR) interfaces, including augmented and virtual reality, create new accessibility barriers from users with sensory or cognitive impairments unless designed inclusively from the outset [32]. Integrated sensing and communication (ISAC) capabilities may enable innovative assistive applications but also raise concerns about surveillance of vulnerable populations. Network slicing could enable tailored service tiers but risks creating stratified access where premium capabilities remain unaffordable for low-income users. The shift toward software-defined, cloud-native architectures concentrates technical complexity, potentially widening the gap between those who can navigate advanced services and those who cannot. Each of these architectural choices has inclusion implications that require proactive industry response.

6G4Society engagement activities indicate **inclusion is among the highest public priorities** for 6G. Surveys and workshops reveal citizens associate connectivity with equality of opportunity and rural community viability. Many expressed frustrations at infrastructure decisions made without consultation and at what they perceive as an urban bias in technological investment. Expert interviews with researchers and project leaders reinforced these concerns, highlighting the neglect of distributive justice (who benefits versus who bears burdens) and procedural justice (whether affected communities have a genuine voice) [4].

Understanding these dynamics requires moving beyond an oversimplified notion of a “digital divide” as merely connected versus unconnected. Two decades of research shows digital inequality unfolds across multiple layers. Even among connected users, differences in skills, literacy, and confidence determine how effectively they benefit, while those with greater social and economic resources consistently derive larger gains. Scholars including Jan Van Dijk, Eszter Hargittai, Ellen Helsper, and Mark Warschauer, reveal that inclusion depends on reinforcing conditions: access, skills, and outcomes must advance together [33], [34], [35], [36], [37]. Van Dijk’s sequential model of access, Hargittai’s second-level digital divide (skills), and Helsper’s third-level divide (tangible outcomes) provide the conceptual foundation for understanding that infrastructure deployment alone does not guarantee inclusion.

Within 6G4Society, **inclusion is therefore understood as the set of conditions that enable all individuals and communities to participate meaningfully in digital life**. It encompasses the capability to use technologies safely and autonomously, achievement of equitable outcomes across life domains, universal accessibility regardless of ability, and the exercise of voice in decisions shaping digital infrastructures. Inclusion, in this sense, is not a technical endpoint but a governance principle essential to 6G legitimacy.

The transition to 6G will magnify consequences of inaction. Early deployments will likely concentrate in profitable urban corridors and industrial zones, while AI-native architectures and advanced interfaces will demand higher digital literacy. Unless policy treats inclusion as a guiding criterion from the outset, Europe risks a two-speed digital society where some enjoy high-performance connectivity while others remain confined to outdated infrastructure and limited opportunity.

3. Operational Recommendations

Aligning 6G deployment with Europe's social model requires industry action across five mutually reinforcing dimensions. The following recommendations translate inclusion objectives into concrete operational practices for network operators, equipment vendors, and service providers.

3.1. R1 – Guarantee equitable infrastructure access and affordability

Universal access to high-quality 6G infrastructure at affordable prices is fundamental to preventing reproduction of existing digital divides. Affordability is also an explicit universal service obligation under the European Electronic Communications Code, which requires Member States to ensure access at an affordable price and to take measures, including special tariff options or packages, when low-income consumers or those with special social needs are prevented from accessing adequate broadband. Without proactive deployment strategies, 6G rollout will concentrate in profitable urban areas, leaving rural and peripheral communities with outdated infrastructure. Industry has both commercial interest and social responsibility to ensure geographic location or economic status does not determine who benefits from next-generation connectivity. Operators who develop viable models for underserved areas position themselves for public co-investment, spectrum preferences, and strengthened community relationships.

Operational options are:

- **Design network architectures for universal coverage:** Evaluate technology options enabling cost-effective rural and low-density deployment: fixed wireless access (FWA) using 6G spectrum, integration with low-earth orbit (satellite) backhaul for remote areas, mesh network topologies reducing backhaul requirements, and small cell densification strategies adaptable to varied population densities. Model coverage economics early in network planning to identify areas requiring alternative technical approaches or public co-investment.
- **Implement transparent, standardised coverage reporting:** Publish detailed coverage maps using standardised methodologies aligned with BEREC guidelines and national regulatory requirements. Report not only coverage footprint but quality metrics including throughput, latency, and reliability at the cell edge. Disaggregate reporting by geographic classification (urban, suburban, rural, remote) to enable identification of underserved areas. Provide machine-readable data formats enabling independent analysis and community access to deployment information.
- **Design meaningful social tariff offerings**: Develop genuinely affordable packages for low-income households that provide adequate service quality, not degraded connectivity. As a pragmatic benchmark for stress-testing affordability, the Broadband Commission's 2025 target recommends that entry-level broadband be priced below 2% of monthly GNI per capita in low and middle-income countries, offering a simple reference point for defining what "meaningful" affordability looks like in practice [3]. Align eligibility criteria with existing social benefit systems to streamline verification and maximise uptake. Ensure social tariff users receive equivalent customer service and network priority. Report on social tariff uptake, usage patterns, and barriers to adoption to enable continuous improvement.
- **Remove barriers to access for vulnerable groups:** Simplify contract and identification requirements, accepting diverse documentation for service activation. Design onboarding processes accessible to users with limited digital experience, language barriers, or disabilities. Train customer service staff to assist users with varied needs, including protocols for supporting older adults, persons with disabilities, and users with low literacy. Offer multiple channel options (in-person, phone, accessible digital) for all service interactions.
- **Leverage European funding mechanisms for inclusive deployment:** Actively pursue available funding through the Connecting Europe Facility (CEF Digital),

Recovery and Resilience Facility, Structural Funds, and national broadband programmes. Develop proposals demonstrating how 6G deployment will address Digital Decade connectivity targets in underserved areas. Structure co-investment arrangements with public authorities for areas where commercial deployment alone is not viable. Participate in public-private partnerships targeting connectivity for schools, healthcare facilities, and public institutions in underserved regions.

3.2. R2 – Build sustainable local digital-skills ecosystems

Addressing persistent digital skills gaps requires moving beyond fragmented, short-term training toward sustainable community-based learning ecosystems. As 6G introduces AI-native architectures and advanced interfaces, **higher digital literacy** will be essential for meaningful participation. Without structured, locally embedded skills initiatives, existing inequalities will widen, leaving older adults, jobseekers, low-income households, and vulnerable groups unable to benefit. Building sustainable skills ecosystems ensures all citizens can use 6G technologies safely, autonomously, and effectively, transforming infrastructure access into genuine capability. Industry involvement in skills development also builds customer competence, reduces support costs, and strengthens community relationships.

Operational options are:

- **Align skills initiatives with the European Competence Framework**: Structure digital literacy programmes around DigComp 3.0 competence areas: information search, evaluation and management; communication and collaboration; digital content creation; safety; and problem solving. Use DigComp proficiency levels (Foundation, Intermediate, Advanced, Highly Specialised) to design learning pathways appropriate for different starting points. Leverage the framework's 500+ learning outcomes to design granular curricula addressing specific competency gaps. Where relevant, enable participants to obtain recognised certifications demonstrating competence acquisition. Track skills development against DigComp indicators to enable comparability and reporting.
- **Develop 6G-specific user competencies**: Identify and address the new skills 6G technologies will require, building on DigComp 3.0's systematic integration of AI competence across all framework areas. Key Competencies include: understanding AI-driven service personalisation and automated decision-making; navigating extended reality (XR) interfaces safely; managing privacy and consent in sensing-enabled environments; configuring network slice preferences where user choice is available; critically evaluating AI-generated content and recommendations; and recognising misinformation in AI-mediated environments. Develop training modules addressing these emerging competencies before 6G services launch to ensure users are prepared.
- **Partner with community organisations for locally-embedded delivery:** Collaborate with libraries, community centres, adult education providers, and civil society organisations to deliver skills programmes in trusted local settings [38]. Co-design curricula with community partners to address locally-identified needs and cultural contexts. Support train-the-trainer approaches that build sustainable local capacity rather than dependence on external providers. Prioritise deployment regions for skills investments to ensure communities gain capability alongside infrastructure.
- **Design accessible, multi-modal training programmes:** Ensure skills programmes are accessible to participants with disabilities, following WCAG 2.1 guidelines for digital materials [39] and providing alternative formats (large print, audio, sign language interpretation) for in-person sessions. Offer multiple learning modalities: self-paced e-learning, facilitated group sessions, one-to-one support, and peer learning. Design mobile-first digital learning resources recognising that many users access training via smartphones. Provide offline-capable materials for users with limited or intermittent connectivity.

- **Contribute tangible resources to skills ecosystems:** Dedicate staff time to community education activities, including technical experts who can explain 6G technologies in accessible terms. Provide equipment (devices, connectivity, demonstration facilities) for training programmes. Offer premises for training sessions where available. Fund instructor development and provide ongoing technical support to training providers.
- **Collaborate with public employment and social services:** Partner with public employment services (PES), social services, and education authorities to integrate digital skills into broader support pathways. Enable referral mechanisms connecting users identified as needing skills support with appropriate programmes. Share anonymised data (with appropriate consent and safeguards) enabling identification of skills gaps and targeted intervention and design. Align skills initiatives with national Digital Skills and Jobs Coalition commitments.
- **Measure and report on skills outcomes systematically:** Track participant competency development using DigComp 3.0 aligned assessments. Report on skills indicators (participation, completion, competency gains, certification) alongside deployment metrics. Disaggregate outcomes by demographic characteristics to identify groups requiring additional support. Use skills data to continuously improve programme design and service accessibility.

3.3. R3 – Implement outcome-focused monitoring and intervention

Shifting from infrastructure-centric to outcome-focused monitoring is essential to ensure 6G deployment produces **tangible improvements in citizens' lives**. Current frameworks emphasise network coverage and speeds but rarely assess whether connectivity translates into real improvements in employment, education, health, and civic participation. The Digital Economy and Society Index (DESI) and Digital Decade monitoring track infrastructure deployment and basic skills, but outcome measurement remains underdeveloped. Without outcome-focused indicators, policymakers lack evidence to identify persistent inequalities or evaluate intervention effectiveness. Strengthening outcome monitoring reveals which groups and regions benefit from 6G and which remain excluded, enabling targeted interventions addressing root causes. Industry engagement in outcome measurement also provides evidence for public investment cases and demonstrates social value creation.

Operational options are:

- **Integrate Key Value Indicators (KVIs) alongside technical KPIs:** Adopt the KVI approach emerging from SNS JU research (including 6G4Society) that complements traditional technical Key Performance Indicators with measures of societal value creation. Define inclusion-relevant KVIs such as: proportion of service area population actively using services; demographic representativeness of user base compared to population; accessibility compliance rates; affordability as percentage of household income (aligned with the internationally recognised 2% threshold [40]); and user-reported capability gains. Report KVIs alongside network performance metrics in regular operational reporting.
- **Measure tangible outcomes across life domains:** Track whether connectivity translates to improved user outcomes in key domains: employment (job search success, remote work participation, skills certification); education (online learning completion, digital assessment participation) health (telehealth utilisation, health information access); civic participation (e-government service use, online democratic engagement); and social connection (communication with family, community participation). Use validated survey instruments and, where possible, linkage to administrative data to assess outcome changes over time.
- **Disaggregate all impact data systematically:** Analyse service quality, usage patterns, and outcomes by demographic and geographic characteristics (age, gender, disability status, income level, education) and geographic classification (urban,

suburban, rural, remote). Apply intersectional analysis recognising that exclusion compounds across multiple dimensions. Identify groups experiencing below-average outcomes and investigate root causes. Use disaggregated data to target service improvements, support interventions, and resource allocation.

- **Conduct social impact assessments before major deployments:** Assess how benefits and burdens of planned deployments will be distributed across populations. Identify potentially excluded populations before deployment using demographic analysis and community consultation. Model affordability impacts across income distributions. Modify deployment plans, pricing, and support provisions to address anticipated negative impacts. Publish impact assessments and mitigation commitments transparently.
- **Contribute to European outcome research infrastructure:** Share anonymised, privacy-preserving data with research institutions studying digital inclusion outcomes. Partner with universities and Eurostat initiatives developing harmonised outcome measurement methodologies. Participate in longitudinal research tracking user cohorts over time to understand sustained impacts beyond initial adoption. Enable evaluation of whether connectivity investment produce genuine, lasting benefit for underserved populations.
- **Establish feedback loops from outcomes to service design:** Create mechanisms linking outcome monitoring to service improvement. Where outcome data reveals persistent gaps, investigate causes and implement targeted responses: adjusted pricing, enhanced support, interface modifications, or partnership interventions. Report publicly on how outcome evidence has informed service changes. Demonstrate commitment to continuous improvement based on inclusion evidence.

3.4. R4 – Embed accessibility-by-design across 6G systems and services

Ensuring 6G technologies are accessible to persons with disabilities and older adults from earliest development stages is both a legal obligation and social imperative. Accessibility is also anchored in disability-rights governance: the UN Convention on the Rights of Persons with Disabilities (CRPD) requires equal access to information and communications, including ICT and systems, as a condition for independent living and full participation [4]. Current accessibility provisions, including EN 301 549 and the Web Accessibility Directive, were designed for existing technologies and **require** extension to address the novel interaction modalities 6G will introduce. Extended reality interfaces, AI-driven voice interactions, haptic feedback systems, and sensing-based services each create new accessibility challenges that must be addressed proactively. Without accessibility by design, next-generation networks will reproduce and amplify existing barriers, preventing millions of Europeans from accessing essential services mediated through 6G infrastructure. Industry leadership on accessibility also open markets, reduces retrofitting costs, and demonstrates social responsibility.

Operational options are:

- **Apply accessibility standards from project inception:** Treat accessibility as baseline requirement for all development, not an afterthought or compliance checkbox. Apply EN 301 549 to all products and services. EN 301 549 is explicitly designed for use in European public procurement and is directly linked to the requirements of the Web Accessibility Directive for public sector websites and mobile applications, making it a concrete compliance bridge between policy obligations and testable technical requirements. Implement Web Content Accessibility Guidelines (WCAG) 2.1 Level AA as minimum for all web and application interfaces, anticipating WCAG 3.0 requirements as they emerge. Use WAI-ARIA (Accessible Rich Internet Applications) specifications for dynamic content and advanced interface components. Document accessibility requirements in technical specifications from earliest design stages.
- **Address 6G-specific accessibility challenges proactively:** Identify and mitigate accessibility barriers arising from novel 6G interaction modalities. For extended reality

(XR) interfaces: ensure alternative access paths for users who cannot use VR/AR; provide audio descriptions and haptic alternatives for visual content; address motion sickness and vestibular concerns. For AI-driven voice interfaces: support diverse speech patterns, accents, and assistive communication devices; provide text alternatives for voice-only interactions. For haptic feedback systems: offer visual and audio alternatives; accommodate users with sensory processing differences. For sensing-based services: ensure informed consent mechanisms are accessible; provide alternatives for users uncomfortable with environmental sensing.

- **Involve disabled people meaningfully in design and testing**: Engage disabled people's organisations (DPOs) and accessibility experts from the earliest development stages, not only for final validation. Establish ongoing advisory relationships with disability communities, not one-off consultations. Conduct usability testing with users across the full spectrum of disabilities: visual, hearing, motor, cognitive, and neurodiverse. Compensate disabled consultants fairly for expertise contributed. Document how user feedback influenced design decisions and communicate changes back to participants.
- **Implement continuous accessibility auditing and remediation:** Conduct regular accessibility assessments using both automated testing tools and expert manual evaluation. Test with actual assistive technologies: screen readers (JAWS, NVDA, VoiceOver), switch access, eye tracking, and voice control. Publish accessibility conformance statements and improvement roadmaps, transparently. Establish rapid remediation processes for identified barriers, with clear timelines and accountability. Track accessibility metrics over time and report progress publicly.
- **Pioneer 6G-enabled assistive technology innovation:** Leverage 6G capabilities to create accessibility innovations beyond compliance: ultra-low-latency real-time captioning and sign language interpretation; AI-powered audio description for visual content; haptic navigation assistance using network positioning; personalised interface adaptation using AI; remote assistance enabling support workers to guide users through complex tasks. Partner with assistive technology developers and research institutions to prototype and validate new accessibility applications. Demonstrate accessibility leadership through innovation, not just compliance.
- **Build accessibility competence across the organisation:** Train all development, design, and customer service staff on accessibility fundamentals and disability awareness. Include accessibility criteria in procurement requirements for third-party components and services. Designate accessibility champions within development teams with authority to halt releases with significant accessibility barriers. Contribute accessibility learnings to industry forums, standards bodies, and open-source communities. Participate in ETSI, 3GPP, and O-RAN accessibility discussions to embed accessibility in 6G specifications from the outset.

3.5. R5 – Strengthen participatory governance and procedural justice

Ensuring affected communities have meaningful voice in infrastructure decisions is fundamental to democratic legitimacy and social acceptance of 6G deployment. Current consultation processes often occur too late to influence design, use inadequate formats, or fail to reach marginalised populations. Without **genuine participatory governance**, 6G rollout will be perceived as imposed from above, eroding public trust and risking the controversies that affected 5G deployment in some regions. The Aarhus Convention establishes the right to public participation in environmental decision-making, applicable to telecommunications infrastructure given its environmental and territorial implications. The European Electronic Communications Code also emphasises stakeholder consultation in spectrum and infrastructure decisions. Industry commitment to meaningful participation builds social licence to operate, reduces deployment conflicts, and generate valuable local knowledge.

Operational options are:

- **Engage communities early, when decisions can still be influenced:** Initiate community engagement before finalising deployment plans, site selections, or service designs, not after decisions are effectively made. Apply the IAP2 (International Association for Public Participation) spectrum of participation [41], moving beyond informing and consulting toward genuine involvement and collaboration where appropriate. Provide information early enough to enable genuine input, with realistic response timelines (minimum 30 days for significant decisions). Be transparent about which aspects of decisions are open to influence and which are constrained.
- **Make participation processes genuinely accessible:** Design engagement processes accessible to all community members, including persons with disabilities, older adults, those with limited digital skills, and non-native speakers. Offer multiple participation channels: in-person meetings, online platforms, written submissions, telephone options, and door-to-door outreach for hard-to-reach populations. Ensure physical venues are accessible; provide sign language interpretation, captioning, and materials in alternative formats. Schedule sessions at varied times to accommodate different work patterns. Provide childcare where feasible to enable parent participation.
- **Deploy inclusive digital participation platforms:** Utilise digital engagement tools (such as Decidim, Consul, or similar open-source civic technology platforms) to broaden participation beyond those who can attend in-person meetings.
  Ensure platforms meet WCAG 2.1 accessibility standards. Combine digital engagement with offline methods recognising that digital-only participation excludes those most affected by connectivity gaps. Provide moderation that ensures respectful dialogue and prevents domination by vocal minorities. Publish all contributions and responses transparently.
- **Translate technical information for non-expert audiences:** Produce plain-language summaries of deployment plans, environmental assessments, and technical specifications. Explain what infrastructure will look like, where it will be located, what services it will enable, and what impacts (positive and negative) are anticipated. Use visualisations, maps, and simulations to help communities understand proposals. Avoid jargon; where technical terms are necessary, explain them clearly. Offer community briefing sessions where residents can ask questions and receive accessible explanations.
- **Establish community benefit arrangements**: Negotiate tangible local benefits for communities hosting infrastructure, going beyond basic connectivity provision. Consider: priority access to new services; community digital hubs in partnership with local authorities; digital skills programmes for local residents; local employment and supplier opportunities during construction and operation; contributions to community funds or facilities. Document commitments formally and report on delivery. Recognise that communities accepting infrastructure burdens (visual impact, construction disruption) deserve corresponding benefits.
- **Create accountability mechanisms for participation outcomes:** Document engagement processes comprehensively, including who participated, what concerns were raised, and how input was addressed. Publish participation reports showing how community feedback influenced final decisions, and explaining clearly where input could not be accommodated and why. Establish complaint mechanisms for communities who believe engagement was inadequate. Build ongoing relationships with affected communities beyond approval-seeking, including regular updates during deployment and channels for ongoing feedback during operation.

3.6. R6 – Reinforce targeted research and coordinated policy support

Addressing inclusion challenges comprehensively requires dedicated research to develop evidence-based approaches and coordinated action across stakeholders. Industry engagement with research initiatives and multi-stakeholder coordination mechanisms is essential to translate inclusion principles into operational practice. Active participation in these ecosystems positions European industry to shape emerging frameworks, contribute practical knowledge, and demonstrate commitment to inclusion beyond compliance.

Operational options are:

- **Contribute operational data to inclusion research:** Share anonymised, privacy-preserving data with research institutions studying digital inclusion, enabling identification of gaps and evaluation of intervention effectiveness. Participate in SNS JU and Horizon Europe research projects addressing inclusion dimensions of 6G. Support development of inclusion-focused Key Value Indicators (KVIs) by providing operational perspectives on measurability and relevance. Enable academic access to network performance data disaggregated by geography and demographics where privacy permits.
- **Engage with European inclusion coordination mechanisms:** Participate in multi-stakeholder inclusion initiatives at European and national levels, including Digital Skills and Jobs Coalition commitments, national broadband competence offices, and accessibility coordination bodies. Collaborate with regulators, civil society organisations, and local authorities on coherent inclusion approaches. Contribute industry perspective to policy consultations on digital inclusion, ensuring operational feasibility of proposed measures.
- **Utilise living labs and testbeds for inclusive design validation:** Leverage SNS JU experimental facilities and national 6G testbeds to validate inclusive design approaches before production deployment. Test accessibility features, multi-modal interfaces, and simplified user experiences with diverse user populations in controlled environments. Pilot community engagement approaches and skills interventions in testbed regions. Share learnings with research community and standards bodies.
- **Build internal co-design and inclusive research capabilities**: Develop organisational capacity for participatory design methods that involve end users, including marginalised groups, throughout development processes. Train product and service teams on inclusive research practices: accessible user testing, ethical engagement with vulnerable populations, and meaningful incorporation of diverse feedback. Document and publish co-design methodologies and learnings to support industry-wide capacity building.
- **Support development of inclusion standards and guidance**: Contribute operational experience to standards bodies (ETSI, 3GPP, O-RAN Alliance) developing accessibility and inclusion provisions for 6G specifications. Participate in CEN/CENELEC working groups on accessibility standards. Engage with BEREC and national regulators on practical implementation of universal service and social tariff requirements. Share implementation learnings that can inform guidance for the sector.

4. Evidence and analysis

Project findings are based on triangulation of quantitative (surveys), qualitative (interviews and workshops), and desk-research methods, ensuring robustness and alignment between citizen, expert, and institutional viewpoints. Survey responses reflect participant perceptions rather than the full EU population, while evidence from SNS JU projects represents early-stage research rather than deployed infrastructures. Nevertheless, the extensive combination of scientific literature, citizen surveys, participatory workshops, interviews with practitioners and experts in acceptance, 6G, green ICT, smart cities and sustainability, consultations with policymakers, and engagement within the SNS JU community provides complementary academic, civic, and institutional perspectives on how societal values are currently represented and operationalised in 6G research and innovation.

Citizen surveys showed 45% of respondents viewed **inclusion and access as key priorities for future connectivity**. Participants highlighted persistent **coverage gaps**, particularly in rural and natural-park areas, and expressed concern that advanced mobile generations benefit urban centres while neglecting those in precarious conditions. Workshops linked connectivity directly to social **justice, equality of opportunity, and community sustainability**.

Expert interviews emphasised the importance of **distributive and procedural justice**, noting that **stakeholder engagement** in technological development often occurs too late to influence design. Consultations with research and innovation projects confirmed that while many acknowledge inclusion as relevant, **few operationalise it** beyond basic access metrics.

The evidence converges on a clear conclusion: inclusion remains a widely articulated public expectation but an **underdeveloped dimension** of current research and deployment practice. Treating it as a **governance principle**, integrating access, skills, equitable outcomes, accessibility, and participation from earliest development stages, is essential to ensuring 6G delivers on Europe's commitment to fairness, cohesion, and democratic legitimacy.

5. Sources

This operational brief synthesises findings from 6G4Society Deliverables D1.1 [2] and D1.2 [1], as well as related outputs under WP2 and WP3. It draws on EU policy frameworks including the Digital Decade Policy Programme, the Gigabit Infrastructure Act, the European Electronic Communications Code, the Digital Education Action Plan, the European Accessibility Act, the Web Accessibility Directive, and the Aarhus Convention on public participation in environmental matters.

Technical and operational guidance draws on: the European Digital Competence Framework (DigComp 3.0) [24]; EN 301 549 [25] and Web Content Accessibility Guidelines (WCAG 2.1) [39]; the Digital Economy and Society Index (DESI) monitoring framework [42]; and BEREC guidelines on universal service and social tariffs [43]. Participation methodologies reference the IAP2 Spectrum of Public Participation [41].

6. Contact details

For further information, contact CyberSocial Lab. at eu-projects@cybersoclab.com or visit www.6g4society.eu. Project deliverables are publicly available through the 6G4Society Zenodo repository at https://zenodo.org/communities/6g4society.

APPENDIX IV – OPERATIONAL BRIEF ON SECURING EUROPE'S TECHNOLOGICAL SOVEREIGNTY IN 6G

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December 2025

TOWARDS A SOCIALLY ACCEPTED AND SUSTAINABLE 6G

Operational Brief on Securing Europe's Technological Sovereignty in 6G

1. Highlights

Europe's technological sovereignty in sixth-generation (6G) mobile network faces increasing risks. Current analysis shows that Europe still produces only around 10% of the world's semiconductors and remains highly dependent on imports for many critical digital technologies [44], while leading-edge chips are manufactured entirely outside European borders [45], [46]. The global telecommunications equipment market is dominated by a small number of large suppliers – especially Huawei, Ericsson, and Nokia – creating oligopoly conditions that limit European strategic choices and increase vulnerability to supply-chain disruptions [47].

While citizen surveys revealed concerns about Europe's competitive position, network reliability, and dependence on external actors, expert consultations with Smart Networks and Services Joint Undertaking (SNS JU) projects confirmed six critical vulnerabilities requiring policy intervention: supply chain dependencies in critical components, fragmentation of global standards processes, risks of foreign government access to European infrastructure, integration with critical sectors creating cascading failure risks, regulatory fragmentation across Member States, and insufficient European capacity for independent technical assessment.

These findings underscore that 6G's success depends not only on technological performance but on ensuring Europe can design, deploy, and govern networks in line with its democratic values while maintaining security and economic competitiveness. Against this backdrop, this brief examines the following question: ***How can Europe develop technological sovereignty for 6G that strengthens security, embeds European values, and maintains global interoperability without resorting to technological isolation?*** It proposes six priority recommendations: 1. Strengthen supply chain resilience through diversification, transparency mechanisms such as Software Bills of Materials (SBOM), and investment in European capacity; 2. Build internal expertise for independent 6G technical assessment, reducing dependence on vendor expertise for critical decisions; 3. Lead in global standards bodies to embed European values in technical specifications through active participation in 3rd Generation Partnership Project (3GPP), O-RAN Alliance, and European Telecommunications Standards Institute (ETSI); 4. Harden systems against foreign government access and interference through zero-trust architectures and supply chain attestation; 5. Align with harmonised European approaches to security, certification, and deployment requirements; 6. Contribute to sovereignty-focused research, certification frameworks, and governance capacity building.

2. Context of the Issue

The debate on technological sovereignty has intensified following the COVID-19 pandemic, supply chain disruptions, and rising geopolitical tensions that exposed **Europe's deep dependencies on foreign technologies** for connectivity, cloud services, and semiconductors. In response, the European Union updated its Industrial Strategy and embraced the concept of "**open strategic autonomy**", seeking to reduce critical dependencies while remaining engaged in global cooperation, maintaining interoperability, and supporting standards-based development [48].

Unlike previous mobile generations that primarily served communications, 6G is being designed as **AI-native infrastructure deeply integrated with critical sectors** including energy, transportation, healthcare, and financial systems. This integration creates novel **vulnerabilities** where foreign control over components or data flows could enable economic coercion, espionage, or disruption of essential services.

The technical architecture of 6G introduces specific sovereignty challenges that industry must address. Cloud-native, software-defined network functions mean that critical operations depend on software supply chains spanning multiple jurisdictions, making Software Bill of Materials (SBOM) tracking essential for transparency. AI-native optimisation implies the need for large-scale data processing that may traverse non-European infrastructure, demanding clear data localisation and sovereignty-aware orchestration. Open RAN disaggregation, while offering vendor diversity and reducing lock-in, also distributes trust across more component interfaces, requiring robust multi-vendor accountability frameworks. Integrated sensing and communication (ISAC) capabilities generate sensitive geolocation and environmental data that becomes a strategic asset requiring protection. Each of these architectural shifts demands corresponding operational responses that go beyond current practice.

Europe has established instruments [49] including the EU Chips Act, the 5G Security Toolbox [50], the NIS2 Directive [51], and STEP to address sovereignty concerns [52]. However, **significant gaps** remain in areas directly relevant to industry practice: comprehensive supply chain mapping for 6G components, sufficient regulatory expertise to govern AI-native networks, coordinated European participation in global standards bodies, frameworks addressing foreign interference in cloud-based architectures, harmonised security approaches across Member States, and integrated critical infrastructure resilience mechanisms.

Analysis within 6G4Society reveals that while citizens rarely used “technological sovereignty” terminology, they expressed **concerns about Europe’s competitive position, dependence on external actors, network reliability, and regulatory lag**. Expert consultations with SNS JU projects confirmed these concerns operationally: **geopolitical competition** risks fragmenting 6G into incompatible regional standards, with governance models embedded in technical specifications shaping how rights and security are distributed [4]. Experts emphasised that sovereignty means retaining **capacity to embed European values** (e.g., transparency, privacy, democratic governance) in 6G design while balancing innovation needs with regulatory safeguards [4].

Within this context, technological sovereignty for 6G encompasses Europe’s capacity to make **autonomous, democratically accountable decisions** about 6G development and governance while remaining interoperable and globally engaged. For industry, this operates across three dimensions: **industrial capacity** (semiconductors, software, equipment), **security autonomy** (preventing foreign control, maintaining verification capability), and **value integration** (embedding European commitments to rights, privacy, transparency in technical design). This aligns with the EU’s “open strategic autonomy” approach, distinguishing European sovereignty from closed, nationalist strategies that risk fragmentation and isolation [48].

3. Operational Recommendations

Aligning 6G deployment with Europe’s vision of technological sovereignty implies the need for industry action across six interconnected areas. The following recommendations translate strategic sovereignty objectives into concrete operational practices for network operators, equipment vendors, and infrastructure developers.

3.1. R1 – Strengthen 6G supply chain resilience and critical industrial capacity

Europe's reliance on non-European suppliers for advanced semiconductors, manufacturing equipment, and key software components creates vulnerabilities to supply disruptions, geopolitical tensions, and strategic dependencies that could compromise autonomous decision-making. While the EU Chips Act [53] and IPCEI mechanisms [54] address strategic dependencies in semiconductors and microelectronics generally, and mapping exercises have identified 137 products in sensitive ecosystems with high external dependencies [55], these efforts have not yet been extended to the specific requirements of 6G networks. The telecommunications sector requires **dedicated supply chain resilience frameworks** that address 6G-specific components including RF equipment, AI accelerators for network intelligence, and software-defined networking infrastructure. Building European capabilities while maintaining cooperation with **trusted partners** enables strategic autonomy without technological isolation.

Operational options are:

- **Implement supply chain transparency through Software Bill of Materials (SBOM):** Generate and maintain SBOMs for all critical software components using standardised formats (SPDX, CycloneDX) [56] [57] as anticipated under NIS2 and the Cyber Resilience Act. Integrate SBOM tracking into CI/CD pipelines to enable automated vulnerability scanning against databases such as the National Vulnerability Database (NVD). Require SBOM documentation from all software suppliers and maintain a centralised repository enabling rapid impact assessment when new vulnerabilities emerge.
- **Adopt Open RAN architectures to reduce vendor lock-in:** Deploy Hardware Security Modules (HSMs) for cryptographic key management and secure boot processes. Require Trusted Platform Module (TPM) attestation for critical network elements to verify firmware integrity. Where feasible, evaluate open hardware architectures (e.g., RISC-V) and European chip designs emerging from EU Chips Act Investments to reduce dependency on proprietary instruction set architectures.
- **Document accountability across multi-vendor deployments:** Create component-level responsibility matrices mapping each network function to its supplier, maintainer, and security contact. Establish incident response protocols that span vendor boundaries with pre-agreed escalation paths and communication channels. Maintain provenance documentation enabling rapid determination of which vendor is accountable for any given failure or vulnerability.
- **Integrate supplier risk scoring into procurement:** Develop vendor risk assessment frameworks that evaluate geopolitical exposure, jurisdictional risks, supply chain depth, and historical security performance. Weight sovereignty considerations alongside price and technical performance in procurement decisions. Prioritise suppliers from democratic, rule-of-law jurisdictions and build relationships with emerging European suppliers, including SMEs supported through IPCEI and Horizon Europe programmes.
- **Communicate supply chain practices transparently**: Publish annual supply chain transparency reports documenting diversification efforts, SBOM coverage, and vendor risk assessments. Engage with regulators and stakeholders on sovereignty practices. Contribute supply chain data to European coordination mechanisms where appropriate.

3.2. R2 – Build independent European governance capacity for 6G oversight

The complexity of AI-native, software-defined 6G networks will significantly exceed current regulatory expertise in most Member States. Existing EU bodies do provide important foundations: The European Union Agency for Cybersecurity (ENISA) offers extensive technical guidance through the EU 5G Toolbox [58], 5G Threat Landscape [59] [60], 3GPP security guidance for regulators [61], and 5G Security Controls Matrix [62] while the Body of European Regulators for Electronic Communications (BEREC) facilitates regulatory coordination and knowledge exchange through its 5G Radar [63] and associated reports [64]. The NIS Cooperation Group has established strategic cybersecurity coordination for 5G networks through the EU coordinated Risk Assessment and 5G Toolbox [65].

However, all these frameworks remain focused primarily on 5G, not the architectural transformations introduced by 6G, including native AI integration, distributed network intelligence, quantum-resistant cryptography, and software-defined 6G architectures. European institutions – regulators, data-protection authorities, and security agencies – currently have limited specialised training in these areas, a gap confirmed by ENISA's cybersecurity skills reports and European Cybersecurity Skills framework [66] [67]. This emerging capacity deficit risks undermining democratic oversight and increasing reliance on the very entities being regulated as 6G deployment approaches.

Operational options are:

- **Build internal expertise on 6G architectural transformations:** Develop staff competencies in the specific technologies that differentiate 6G from previous generations: software-defined networking (SDN) and network function virtualisation (NFV), RAN Intelligent Controllers (RIC) and O-RAN architectures, AI/ML model lifecycle management, and post-quantum cryptography (PQC) migration paths. Create dedicated roles responsible for sovereignty and governance considerations in technical decisions. Ensure engineering teams understand how architectural choices affect auditability, accountability, and democratic oversight.
- **Implement AI transparency and documentation practices:** Maintain comprehensive documentation for all AI systems used in network management and optimisation, including model cards specifying training data provenance, performance characteristics, known limitations, and intended use cases. Adopt explainable AI (XAI) techniques where feasible to enable meaningful human oversight of automated network decisions. Document AI model versioning, update procedures, and rollback capabilities to support external review.
- **Prepare for post-quantum cryptography transitions:** Monitor National Institute of Standards and Technology (NIST) Post-Quantum Cryptography (PQC) standardisation and begin inventory of cryptographic dependencies across network infrastructure. Develop migration roadmaps for transitioning to quantum-resistant algorithms (e.g., ML-KEM, ML-DSA, SLH-DSA) [68] [69] [70] in key management, authentication, and secure communications. Engage with ETSI Quantum-Safe Cryptography working group and relevant 3GPP study items.
- **Enable independent verification and audit**: Design network architectures with auditability as a first-class requirement. Provide comprehensive technical documentation enabling regulator review, including architecture diagrams, data flow mappings, and security control implementations. Support external audits and third-party security assessments. Implement logging and monitoring systems that create verifiable audit trails for critical network operations and AI-driven decisions.
- **Contribute to regulatory capacity building**: Participate actively in regulator training initiatives and knowledge exchange programmes. Share technical expertise with national regulatory authorities, data protection authorities, and ENISA. Contribute to developing sector-specific guidance that bridges the gap between 5G-focused frameworks and 6G architectural realities. Offer secondment opportunities or technical briefings to build regulator understanding.
- **Experiment with participatory oversight mechanisms:** Pilot new approaches to stakeholder engagement in technical decisions affecting communities. Test mechanisms for incorporating public input on deployment choices, particularly for sensitive applications such as sensing and positioning. Document and share learnings on democratic oversight models with industry peers and regulators.

3.3. R3 – Lead in global 6G standards development to embed European values

While European companies are key participants in 3GPP, ITU, and ETSI standards processes [71], the EU still lacks a 6G-specific strategy for systematically translating its legal and ethical requirements into coordinated positions in these fora. The 2022 EU Strategy on Standardisation outlines a values-based approach and calls for stronger coordination, but its measures remain general and not tailored to 6G technical specifications [72]. Existing initiatives such as the EU Standardisation Booster provide project-level support, yet there is no dedicated long-term mechanism to sustain European expert leadership in 6G standardisation [73]. Civil-society organisations also note that the current system provides limited venues for public-interest oversight, calling for more democratic governance of standardisation [74]. As major global actors explore separate 6G standards pathways, this lack of sustained support and oversight increases the risk that European legal and ethical requirements will not be fully reflected in future technical architectures [71].

Operational options are:

- **Commit sustained resources to strategic standards and participation:** Dedicate expert staff to key standards bodies shaping 6G architecture: 3GPP RAN and SA working groups (particularly SA1 for service requirements, SA2 for architecture, SA3 for security, SA5 for management), ITU-T Study Group 13 (Future Networks) and Focus Group on Network 2030, and ETSI groups on NFV, MEC (Multi-access Edge Computing), and Reconfigurable Intelligent Surfaces. Support European candidates for leadership positions (working group chairs, rapporteurs) in these bodies. Coordinate positions with European industry peers through 6G-IA and SNS JU mechanisms to present unified European perspectives.
- **Translate European values into concrete technical contributions:** Develop standards contributions that operationalise European requirements in technical specifications. Privacy-by-design principles should inform proposals on data minimisation in network signalling, consent mechanisms for sensing data, and anonymisation requirements for network analytics. Transparency requirements should shape proposals on AI model documentation, algorithm auditability hooks, and explainability interfaces. Security-by-design should drive contributions on zero-trust architecture patterns, supply chain attestation protocols, and quantum-resistant security frameworks. Document the values-to-specifications mapping to enable consistent advocacy across working groups.
- **Engage actively with O-RAN Alliance technical development:** Participate in O-RAN Alliance working groups, particularly WG1 (Use Cases), WG2 (Non-RT RIC), WG3 (Near-RT RIC), and WG4 (Open Fronthaul), to ensure open interfaces support European sovereignty and security requirements. Contribute to O-RAN security specifications and advocate for privacy preserving approaches in RAN Intelligent Controller (RIC) applications. Engage with O-RAN ALLIANCE's 6G Research Group to shape the evolution of open architectures toward next-generation networks.
- **Contribute to and leverage open-source reference implementations:** Support open-source projects that demonstrate European standards contributions in working code: O-RAN Software Community (OSC) for RAN disaggregation, ONAP (Open Network Automation Platform) for network orchestration, OpenAirInterface for 5G/6G protocol stacks, and the Sylva project for European telco cloud infrastructure [75]. Contribute to engineering resources, code, and testing to these communities. Use open-source implementations to validate technical feasibility of European proposals before standardisation, strengthening negotiating positions with demonstrated implementations.
- **Build coalitions for European positions:** Coordinate with European industry peers, research institutions, and SNS JU projects to develop shared positions before major standards meetings. Engage with like-minded international partners (e.g., through EU-US Trade and Technology Council, EU-Japan, and EU-Korea digital partnerships) to

build broader coalitions supporting interoperable, values-aligned standards. Participate in 6G-IA working groups and policy discussions to align industry positions with European strategic objectives.

- **Monitor and report on standards developments with sovereignty implications:** Track standards proposals from all major contributors that could affect European sovereignty, security, or values integration. Assess implications of competing proposals for European interests and flag concerns through appropriate coordination channels. Report to European coordination mechanisms on standards developments requiring policy attention.

3.4. R4 – Enhance protections against foreign government access and interference

Existing frameworks including the 5G Security Toolbox and NIS2 Directive already provide common approaches to vendor risk assessment and cybersecurity obligations for 5G networks and other essential services [76] [51]. However, they were conceived for current generations of networks and do not yet systematically address the specific threat model of AI-native, cloud-based 6G architectures – including large-scale virtualisation, pervasive remote-management functions and more complex software supply chains. The EU's coordinated 5G risk assessment and subsequent toolbox already highlight non-technical vulnerabilities, such as dependencies on suppliers subject to third-country laws and possible foreign interference through those suppliers. In parallel, European case law and guidance on international data transfers, notably *Schrems II* and the EDPB's Guidelines on Article 48 GDPR, emphasise the systemic risk of foreign government access to data via extra-territorial legal orders [77] [78]. As 6G would become tightly integrated with critical infrastructures in sectors such as energy, transport, healthcare and finance, these combined technical and legal exposure points could enable not only surveillance, but also disruption of essential services if not proactively mitigated.

Operational options are:

- **Implement zero-trust architecture principles:** Design network architectures assuming breach, requiring continuous verification of all users, devices, and network functions regardless of location or prior authentication. Implement micro-segmentation to limit lateral movement within networks. Apply least-privilege access controls to all management interfaces, APIs, and inter-component communications. Deploy identity-aware proxies and software-defined perimeters for all remote access, eliminating implicit trust based on network location.
- **Deploy confidential computing for sensitive workloads:** Utilise Trusted Execution Environments (TEEs) such as Intel SGX, AMD SEV, or Arm CCA [79] [80] [81] [82] to protect sensitive data and processes even from privileged systems administrators or compromised hypervisors. Implement confidential computing for subscriber data processing, key management, and AI model inference where network intelligence operates on sensitive inputs. Ensure that data remains encrypted during processing, not only at rest and in transit, to mitigate risks from foreign access to physical infrastructure or cloud platforms.
- **Establish cryptographic supply chain attestation**: Implement code signing for all software components, firmware, and configuration updates using European-controlled certificate authorities where feasible. Deploy secure boot chains with hardware roots of trust (TPM, HSM) to verify integrity from power-on through application loading. Require cryptographic attestation from suppliers demonstrating software provenance, build environment integrity, and absence of tampering. Verify attestations automatically before deploying updates to production systems.
- **Harden against covert exploitation and exfiltration**: Conduct security assessments specifically targeting supply chain risks, including analysis of third-party libraries and dependencies for hidden functionality. Implement mandatory code review and static/dynamic analysis for all critical software, with particular attention to network-

facing components and management interfaces. Deploy network traffic analysis and AI-driven anomaly detection to identify covert data channels, beaconing behaviour, or unauthorised command-and-control communications. Test for steganographic exfiltration and protocol-level covert channels.

- **Implement sovereignty-aware data routing and processing**: Design orchestration systems to enforce data localisation policies, ensuring sensitive data categories remain within European jurisdiction unless explicitly authorised. Implement policy engines that automatically route workloads to sovereignty-compliant infrastructure. Maintain real-time visibility into data flows across the network, enabling rapid identification and remediation of policy violations. Apply encryption with European-held keys for any data that must transit non-European infrastructure.
- **Engage actively with European security coordination:** Participate in ENISA-led security initiatives, including threat intelligence sharing through the EU Cybersecurity information and Intelligence Sharing Network: Contribute to NIS Cooperation Group activities and national CSIRT coordination. Support coordinated vulnerability disclosure and incident response across European operators. Engage with the European Cybersecurity Competence Centre (ECCC) and national coordination centres on emerging threats specific to 6G architectures.

3.5. R5 – Harmonise Member State approaches to 6G security and deployment

Despite common EU objectives, Member State implementation of the 5G Security Toolbox remains uneven. While a majority of countries are applying or preparing restrictions on high-risk vendors, others have not yet taken equivalent steps, and security aspects are still not addressed in a fully concerted manner across the Union [83] [84]. This fragmentation may create vulnerabilities that malicious actors can exploit, increases compliance costs for operators working across borders, and weakens overall European security. Differences in national approaches to spectrum assignment, vendor restrictions, and security obligations similarly undermine the coherence required for effective technological sovereignty in 6G [83]. Industry can play a constructive role in driving harmonisation by implementing consistent practices that exceed minimum requirements and demonstrating the feasibility of unified approaches.

Operational options are:

- **Align security implementations with EU Cybersecurity Certification Framework:** Prepare for and pursue certification under emerging European cybersecurity certification schemes, including EUCC (Common Criteria-based), EUCS (cloud services), and anticipated 6G-specific schemes. Implement security controls aligned with ENISA's 5G Security Controls Matrix as a baseline, extending coverage to 6G-specific architectural elements as guidance evolves. Where operating across multiple Member States, pursue certifications recognised Union-wide to reduce duplication and demonstrate consistent security posture. Engage with ENISA and national certification authorities during scheme development to ensure practical implementability.
- **Implement uniform security standards across all EU operations**: Apply the highest applicable security standards across all Member State operations rather than calibrating to minimum local requirements. Develop internal security baselines that meet or exceed the most stringent national implementation of EU frameworks. Document security architectures, controls, and processes in standardised formats enabling cross-border consistency verification by regulators. Maintain centralised security governance with local compliance validation to ensure uniform implementation.
- **Ensure network slicing isolation meets cross-border requirements:** Implement cryptographic isolation between network slices to guarantee that security properties are maintained as slices traverse national boundaries. Apply consistent slice security policies regardless of which Member State's infrastructure hosts specific slice components. Deploy slice-aware security monitoring that maintains visibility across

distributed slice deployments. Document slice isolation mechanisms and security guarantees to enable regulatory verification in all jurisdictions where slices operate.

- **Harmonise spectrum usage and interference management**: Coordinate spectrum utilisation practices with operators in adjacent Member States to prevent cross-border interference, particularly for new 6G spectrum bands. Implement dynamic spectrum sharing mechanisms that respect harmonised European spectrum assignments. Participate in CEPT and RSPG processes to support coordinated European spectrum policy. Deploy spectrum monitoring and interference detection capabilities that support cross-border coordination.
- **Contribute actively to harmonisation processes:** Engage constructively with national regulators, sharing technical expertise to support consistent implementation of EU frameworks. Participate in NIS Cooperation Group consultations, ENISA working groups, and BEREC initiatives developing harmonised approaches. Provide implementation experience and practical feedback to European bodies developing 6G security guidance. Support peer learning among regulators by facilitating cross-border regulatory dialogues and technical exchanges.
- **Report transparently on sovereignty and harmonisation metrics**: Provide data supporting Digital Decade monitoring and European sovereignty assessments. Document and publish key sovereignty-relevant metrics: supply chain European content, certification status, cross-border security consistency, and standards participation. Contribute to industry-wide benchmarking initiatives that demonstrate collective progress on harmonisation. Track and report on implementation of 5G Security Toolbox measures and readiness for 6G-specific requirements.

3.6. R6 – Reinforce targeted research and coordinated policy support

Addressing technological sovereignty challenges requires both dedicated research to develop evidence-based frameworks and systematic capacity building to enable implementation. Without coordinated support, European regulators and technology providers risk approaches that fail to achieve collective sovereignty objectives. Industry engagement with research initiatives, governance development, and European digital infrastructure projects is essential to translate sovereignty principles into operational reality. Active participation in these ecosystems also positions European industry to shape emerging frameworks rather than merely comply with them.

Operational options are:

- **Engage with European cloud and infrastructure sovereignty initiatives:** Participate actively in Gaia-X federation services development, contributing to specifications for sovereign cloud interoperability and data exchange [85]. Engage with IPCEI-CIS (Important Project of Common European Interest on Cloud Infrastructure and Services) projects to support development of European cloud capabilities. Adopt and contribute to the Sylva project, the European open-source telco cloud stack, to reduce dependence on non-European cloud platforms for network function hosting. Evaluate European cloud providers aligned with sovereignty requirements for non-critical workloads as a pathway to broader adoption.
- **Contribute to sovereignty-focused research programmes:** Partner with universities and research institutions on sovereignty-relevant research, including supply chain resilience, AI governance for networks, and post-quantum cryptography migration. Participate in SNS JU research projects addressing sovereignty dimensions of 6G architecture. Enable research access to relevant operational data (appropriately anonymised) and infrastructure for academic investigations. Contribute practical industry expertise to Horizon Europe projects examining technological sovereignty, ensuring research outputs are operationally relevant.
- **Develop and implement Key Value Indicators (KVIs) for sovereignty**: Integrate sovereignty-related KVIs into internal performance measurement alongside traditional

technical KPIs. Track metrics such as European supply chain content, data localisation compliance, certification coverage, standards body participation, and open-source contribution. Use KVI frameworks emerging from SNS JU projects (including 6G4Society) to benchmark sovereignty performance and identify improvement priorities. Report on KVIs transparently to demonstrate industry commitment to European sovereignty objectives.

- **Utilise European testbeds for sovereignty-compliant validation**: Leverage SNS JU experimental facilities and national 6G testbeds to validate sovereignty-compliant architectures before production deployment. Test supply chain transparency mechanisms, data localisation enforcement, and cross-border security consistency in controlled environments. Use digital twin technologies to model sovereignty implications of architectural choices. Share testbed learnings with European research community and standard bodies to inform specification development.
- **Prepare proactively for emerging certification requirements:** Align internal security and sovereignty practices with anticipated EU cybersecurity certification criteria (EUCC, EUCS, potential 6G-specific schemes). Participate in certification framework development through ENISA consultations and stakeholder processes. Conduct gap assessments against draft certification requirements and develop remediation roadmaps. Support standardised approaches to security and sovereignty verification that enable mutual recognition across Member States.
- **Contribute to European governance capacity building:** Participate in training and knowledge-exchange initiatives organised by ENISA, 6G-IA, and national competent authorities. Contribute industry perspective to governance development, ensuring operational feasibility of proposed requirements. Support secondment programmes and technical briefings that build regulator understanding of 6G technologies. Engage with the European Cybersecurity Competence Centre (ECCC) and national coordination centres on sovereignty-related research and training priorities.

4. Evidence and analysis

The project's findings are based on a triangulation of quantitative (surveys), qualitative (interviews and workshops), and desk-research methods, ensuring robustness and alignment between citizen, expert, and institutional viewpoints. Survey responses reflect the perceptions of participants rather than the full EU population, while evidence from SNS JU projects represents early-stage research rather than deployed infrastructures. Nevertheless, the combination of methods provides complementary academic, civic, and institutional perspectives demonstrating where current frameworks require strengthening and where industry action can address sovereignty gaps.

Desk research examined EU policy documents on industrial strategy, open strategic autonomy, cybersecurity, and digital regulation, tracing how European policy **thinking evolved from viewing telecommunications primarily as market competition to treating digital infrastructure as strategic assets** with direct implications for security, democracy, and economic resilience. Analysis of the EU Chips Act, 5G Security Toolbox, NIS2 Directive, and related frameworks revealed the gaps identified in this brief, particularly the absence of 6G-specific guidance on supply chain transparency, AI-native network governance, and sovereignty-aware architecture design.

Citizen surveys revealed that **concerns related to technological sovereignty,** while not always expressed in those terms, rank among public priorities for future connectivity. Participants expressed concerns about Europe's competitive position in digital infrastructure, dependence on external actors, network reliability, and regulatory capacity to keep pace with technological change. Citizens highlighted Europe lagging behind China and the US in global competition, the dominance of a small number of large telecommunications providers, and slower legislative response than technology requires. These concerns highlight public expectations that European industry will take proactive steps to strengthen sovereignty, not merely await regulatory mandates.

Expert consultations within SNS JU projects achieved approximately 80% coverage of the ecosystem, through 63 survey responses and targeted interviews with project members and technical leads. These consultations confirmed citizen concerns operationally, highlighting: vulnerability from reliance on foreign semiconductor and equipment suppliers; concentration of critical software and cloud services in non-European hands; accountability gaps in multi-vendor networks; and geopolitical dimensions of standards development, where diverging regional strategies risk non-interoperable systems embedding different governance models. Experts emphasised that sovereignty requires not only policy frameworks but concrete industry practices, supply chain transparency, European cloud adoption, active standards participation, and architectural choices that preserve auditability and democratic oversight.

These findings align with broader European analyses documenting **high import dependence** for critical digital technologies and uneven implementation of security frameworks across Member States. Together, the evidence yields a consistent conclusion: technological sovereignty is not simply industrial policy but a **practical prerequisite for ensuring 6G infrastructures can be governed in line with European law and values**, **and industry action is essential to achieving it.**

5. Sources

This operational brief synthesises findings from 6G4Society project's deliverables D1.1 [2], D1.2 [1], as well as WP2 and WP3 outputs on stakeholder engagement and liaison with the SNS JU community. It is framed within the wider EU policy context defined by the Updated Industrial Strategy (2021), the concept of open strategic autonomy, the EU Chips Act, the Digital Decade Policy Programme, the Cyber Resilience Act, the NIS2 Directive, the Cybersecurity Act.

Technical and operational guidance draws on: the ENISA 5G Security Toolbox and 5G Security Controls Matrix; EU Cybersecurity Certification Framework (EUCC, EUCS); 3GPP security specifications; O-RAN Alliance security and architecture specifications [86]; NIST Post-Quantum Cryptography standards; and Gaia-X federation services documentation. Industry initiatives referenced include the O-RAN Software Community (OSC), ONAP, OpenAirInterface, and the Sylva European telco cloud project. European coordination mechanisms include IPCEI-CIS, the European Cybersecurity Competence Centre (ECCC), and the Strategic Technologies for Europe Platform (STEP).

6. Contact details

For further information, contact CyberSocial Lab. at eu-projects@cybersoclab.com or visit www.6g4society.eu. Project deliverables are publicly available through the 6G4Society Zenodo repository at https://zenodo.org/communities/6g4society.

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Co-funded by the European Union