Smart Networks and Services International and European Cooperation Ecosystem

D1.2 Impact analysis and SNS promotional report 2.0

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Abbreviations List

Abbreviation / Term	Description
3GPP	3rd Generation Partnership Project
5G	Fifth Generation Networks
5G AA	5G Automotive Association
5G-ACIA	5G Alliance for Connected Industries and Automation
5G-MAG	5G Media Action Group
5GMF	5G Mobile Communication Promotion Forum (Japan)
5GPPP	5th Generation Public Private Partnership
6G	Sixth Generation Networks
6G-IA	6G Smart Networks and Services Industry Association
AENEAS	Association for European Nano-Electronics ActivitieS
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
ATIS	Alliance for Telecommunications Industry Solutions
B5G	Beyond 5G
B5GPC	Beyond 5G Promotion Consortium
CAM	Connected and Automated Mobility
CEF	Connected European Facility
CI/CD	Continuous Integration/Continuous Development
CJU	Chips Joint Undertaking
CSA	Coordination and Support Action
CSI	Channel State Information
CT	Core Network and Terminals
DEP	Digital Europe Programmes
DIH	Digital Innovation Hub
DT	Digital Twin
ECSO	European Cyber Security Organisation
EIM	European Rail Infrastructure Managers
eMBB	E10nhanced Mobile Broad-Band
EMF	Electromagnetic Field Exposure
ENI	Esper
ERTICO	Experiential Networked Intelligence
ESA	European Space Agency
ETSI	European Telecommunications Standards Institute
EU	European Union
EuCNC	European Conference on Networks and Communications
FEM	Front-End Module
FR	Frequency Range
GA	Grant Agreement
GNSS	Global Navigation Satellite System
GR	Group Report
GSMA	GSM Association
HEU	Horizon Europe
HPC	High-Performance Computing

ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IPCEI-CIS	Important Project of Common European Interest on Cloud Infrastructure and Services
IPR	Intellectual Property Rights
IRTF	Internet Research Task Force
IMT	International Mobile Telecommunications
IMT 2030 PG	International Mobile Telecommunications 2030 Promotion Group
IoT	Internet of Things
ISAC	Integrated Sensing And Communication
ISG	Industry Specification Group
ITU	International Telecommunication Union
JU	Joint Undertaking
KPI	Key Performance Indicator
MEC	Multi-Access Edge Computing
MIMO	Multiple Input Multiple Output
ML	Machine Learning
MoU	Memorandum of Understanding
MRP	Market Representation Partner
NFV	Network Function Virtualization
NGMN	Next Generation Mobile Networks
NICT	National Institute Of Information And Communications Technology
NR	New Radio
NSF	National Science Foundation
NTN	Non-Terrestrial Networks
NTT	Nippon Telegraph and Telephone
OCF	OpenCAPIF
O-RAN	Open RAN
OSL	Open Slice
OTA	Over the Air
PAWR	Platforms for Advanced Wireless Research program
PPDR	Public Protection and Disaster Relief
PQC	Post Quantum Computing
PSCE	Public Safety Communications Europe
QKD	Quantum Key Distribution
R&D	Research & Development
R&I	Research and Innovation
RAN	Radio Access Network
RINGS	Resilient & Intelligent NextG Systems
RIS	Reconfigurable Intelligent Surfaces
SA	System Aspects
SB	Steering Board
SCoDIHNet	Smart Connectivity Digital Innovation Hub Network
SDG	Sustainable Development Goals
SDG	Software Development Group
SDO	Standards Developing Organization
SNS	Smart Networks and Services

SNS-JU	Smart Networks and Services Joint Undertaking
SNS OPS	Smart Networks Services Joint Undertaking (SNS JU) operations
SRIA	Strategic Research and Innovation Agenda
TCI	Trans Continuum Initiative
TFS	TeraflowSDN
THz	Tera Hertz
T&P	Trials & Pilots
TAICS	Taiwan Association of Information and Communication Standards
TB	Technology Board
TDD	Time Division Duplex
TCI	Transcontinuum Initiative
TRL	Technology Readiness Level
TSDSI	Telecommunications Standards Development Society, India
TSN	Time Sensitive Networking
TTC	Trade and Technology Council
TSG	Technical Specification Group
UC	Use Case
UN	United Nations
URLLC	Ultra-High Reliability & Low Latency Communications
VR	Virtual Reality
WGs	Working Groups
WP	Work Package
WRC	World Radio-communication Conference
XGMF	XG Mobile Promotion Forum
XR	Extended Reality
ZSM	Zero touch network Service Management

Executive Summary

The SNS ICE Coordination and Support Action (CSA), launched in January 2023, acts as the global ambassador of SNS-JU, connecting its R&I projects with international B5G/6G initiatives and fostering collaboration across three main pillars: International Collaboration, EU Research Environment, and Vertical Engagement. Each pillar is managed through dedicated Work Packages (WPs), with WP1 focusing on international collaboration.

This deliverable, D1.2, focuses on the work carried out by SNS ICE under WP1 in 2024, the second year of project execution. Specifically, it provides a timely update on EU & global trends on 6G, this including standardization efforts, definitions of global use cases and an in-depth analysis on trials & pilots analysis being carried out worldwide (Section 2). It also reports on project's contributions towards establishing a truly global 6G ecosystem via Memorandums of Understanding (MoUs) with worldwide organizations and selected verticals; its overall approach to consensus building, and SNS ICE's contribution to the definition of future SNS R&I Work Programmes (Section 3). In addition, deliverable D1.2 also includes detailed information on project's participation in major international events such as 5G Techritory 2024 and EuCNC & 6G Summit 2024, as well as other international events. All the above is accompanied with key insights based on SNS ICE analysis, as well as recommendations for European stakeholders including the SNS Office, and for the forthcoming reporting period and project follow up.

Section 2 reveals that the global 6G landscape is rapidly advancing, with international stakeholders aligning around key priorities outlined in the ITU's IMT-2030 Recommendations. These include sustainability, energy efficiency, trustworthy networks, AI-native intelligence, integrated sensing and communication (ISAC), cloud-native and edge computing, and non-terrestrial networks (NTN) for ubiquitous connectivity. Spectrum efficiency and innovative sharing methods also play a central role in managing increasing data traffic demands.

It is noteworthy that emerging use cases focus on autonomous mobility, immersive communications (AR/VR/XR), digital twins for real-time management, and cooperative robotics. Resilient networks for remote areas and human-centric services like healthcare and public safety are also emphasized. Europe leads in shaping 6G standards through collaborations with ITU, ETSI, and 3GPP while focusing on transformative verticals like Industry 4.0, automotive, and smart cities. AI and edge computing are central to achieving energy efficiency, low latency, and reliability.

Standardization progresses through the 3GPP roadmap, with Release 20 (2025) and Release 21 (2030) delivering key technical specifications. ETSI complements this with initiatives like Terahertz communications and zero-touch networks. Global trials in Japan, China, and the US drive innovation in AI, spectrum, and infrastructure.

Consensus is forming on sustainability, privacy and security, and AI as core pillars for 6G. Europe's leadership positions it to address societal challenges, but reliance on non-European cloud providers highlights the need for technological sovereignty. Overcoming technical challenges in energy efficiency and reliability will require collaboration and research. By expanding efforts into underrepresented sectors like agriculture and education, and prioritizing open, interoperable solutions, 6G can address global priorities and foster transformative innovation.

As explained in **Section 3**, the global 6G ecosystem is evolving rapidly, driven by active MoUs that promote collaborative research, innovation, and standardization. In Europe, SNS ICE and 6G-IA have been pivotal in establishing partnerships with organizations such as ETSI and ESA, fostering leadership in technology standards and innovation. Globally, collaborations with entities like the Next G Alliance (USA) and Bharat 6G Alliance (India) highlight efforts to harmonize research, policy, and standards, emphasizing interoperability and integration of advanced technologies such as AI and NTNs. SNS ICE very actively contributes to translating these MoUs into action through workshops, joint research, and standardization activities, ensuring secure, resilient networks and advancing digital inclusion. Besides, publicly available position papers and roadmaps articulate Europe's 6G vision, addressing societal and technological challenges while fostering global dialogue to achieve consensus on 6G development.

The integration of global collaborations into the SNS R&I Work Programme further aligns European leadership with international advancements. SNS JU projects focusing on international collaboration tackle critical challenges such as sustainable network architectures and intelligent spectrum management. Initiatives like IPCEI-CIS and coordination with DEP and CEF bolster Europe's telco-cloud and infrastructure capabilities, reducing dependency on external technologies and ensuring competitiveness.

The 2025 SNS Work Programme adopts a stakeholder-driven approach, ensuring alignment with industry and research needs. Focus areas include spectrum management, AI-enhanced network automation, and integrating terrestrial and non-terrestrial networks. With respect to previous Work Programmes, in 2025 it prioritises higher Technology Readiness Level (TRL) levels, bridging research and deployment. The inclusion of initiatives like the Front-End Module (FEM) addresses efficient spectrum utilization, while trials in vertical domains like Public Protection and Disaster Relief validate applications, ensuring Europe remains at the forefront of global 6G innovation.

Section 4 highlights SNS ICE's participation in international workshops and events to promote the European 6G vision and foster global collaboration. Key events, such as the 5G Techritory 2024 and EuCNC & 6G Summit 2024, provided platforms to showcase European advancements and align global strategies. Discussions focused on the transition from 5G to 6G, use cases, standardization, and technological innovations. Workshops facilitated by SNS ICE emphasized trials and pilots for emerging 6G use cases and advanced technologies like AI-powered networks and integrated sensing. These sessions bridged European efforts with global trends, contributing to unified strategies on telco cloud evolution and spectrum management.

Participation in events such as the Global 6G Development Conference and EU-Taiwan 6G Workshop strengthened cooperation with global partners. Insights from these engagements shaped updates to the SNS R&I Work Programme, prioritizing experimental validation in vertical domains like Public Protection and Disaster Relief. These activities underscore SNS ICE's role in advancing Europe's leadership in global 6G development.

In **Section 5**, the project provides recommendations to sustain and expand the impact of SNS ICE in advancing Europe's leadership in 6G. It highlights the importance of strengthening international collaborations through additional MoUs, workshops, and joint initiatives. Continued participation in global events is emphasized to showcase European contributions and align efforts with global priorities. It also recommends continuing to refine the SNS R&I Work Programme through industry consultations and prioritizing trials in AI-driven networks and Integrated Sensing and Communication (ISAC). Strategic investments in projects like IPCEI-CIS are advised to enhance technological sovereignty, ensuring 6G innovations meet market and societal needs while maintaining Europe's competitive edge. The deliverable closes by highlighting the main conclusions and lessons learnt in **Section 6**.

1 Introduction

On January 1, 2023, the Smart Networks and Services Joint Undertaking (SNS-JU) launched 33 Research and Innovation (R&I) projects (Phase 1), aimed at advancing next-generation network research in Europe. These projects explore innovative technologies, devices, and software for future networks and are aimed to establish experimentation facilities for trials to assess performance and shape 6G development. On January 1, 2024, 26 additional projects commenced, 16 more will kickstart on January 1, 2025, and more planned annually until 2030.

To promote a unified global 6G standard, SNS-JU prioritizes strong interactions with international stakeholders and active participation in 6G discussions. This facilitates a continuous exchange of updates and insights, to ensure that the EU remains a key player in global network advancements. The SNS ICE Coordination and Support Action (CSA), launched in January 2023, serves as SNS-JU's global ambassador, connecting its R&I projects with international B5G/6G initiatives, programs, and partnerships. To accomplish its mission the SNS ICE project works along three main pillars, namely:

- International Collaboration
- EU Research Environment
- Vertical Engagement

A separate Work Package (WP) has been dedicated to each of these activities, providing dedicated services to the respective stakeholders. This document is the second deliverable of WP1 on International Collaboration and provides a report on all relevant activities during the second year of the project (January to December 2024).

1.1 Background and Context

As discussed in deliverable D1.1, the international collaboration strategy of SNS ICE under WP1 is structured around a series of interlinked tasks, where each step informs the next. It begins with a comprehensive trend analysis of the 6G research landscape nationally, within the EU, and globally. This analysis identifies similarities and differences with the SNS approach at both national and international levels, highlighting key research trends, critical KPIs, targeted use cases, and overarching visions. These insights provide valuable input for SNS researchers.

Armed with this knowledge, SNS researchers and industry leaders participate in international events (organised or supported by SNS ICE) to showcase the EU's vision, research priorities, and outcomes from SNS projects. These engagements aim to foster dialogue and build consensus on pivotal technical matters.

The international collaboration strategy of SNS ICE under WP1 involves a series of interconnected tasks. First, a detailed trend analysis of the EU and worldwide landscape in terms of 6G research must take place, in order to identify commonalities and differences with the SNS approach either at a National EU level or at an international level. This analysis creates awareness regarding the hot research topics, main Key Performance Indicators (KPIs), targeted use cases, visions, etc. that the rest of the work is focusing on, which constitutes important input for the SNS researchers. Equipped with this knowledge, the SNS researchers and industrial leaders may participate in international events (organised or facilitated by SNS ICE) to promote the EU vision, research directions, results and insights from SNS projects and to engage in discussion pursuing consensus on important technical issues.

This approach, along with the increased synergies that such interactions will create, are the optimum way to enforce the belief in a common global 6G standard. The activities of this WP come to a full circle with the monitoring and reporting of the impact all these steps have on the global landscape and 6G research community.

Figure 1 illustrates the core activities pursued by the SNS ICE project within the framework of the International Collaboration strategy and how they are interconnected.

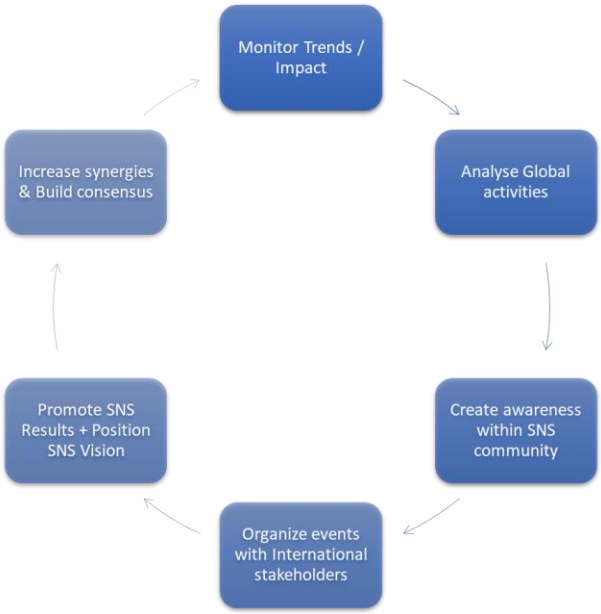

Figure 1: International Collaboration flow of activities.

1.2 Mapping of Outputs

The International Collaboration efforts within WP1 are divided into three distinct tasks, each with clearly defined objectives outlined in the Grant Agreement (GA). This deliverable outlines the progress and status of all three WP1 tasks during the second year of the SNS ICE project. Table 1 highlights how the various GA components assigned to WP1 are addressed throughout the document.

Table 1 offers a mapping of the various GA components that WP1 aims to accomplish and indicates where they are addressed within the document.

Table 1: Matching of deliverable content to Grant Agreement components.

GA Component Title	GA Component Outline	Respective Document Section(s)	Justification
TASKS			
Monitor trends	Analysis of global B5G/6G trends	Section 2.1	This analysis of global B5G/6G trends within 2024 (second year of the SNS project) establishes the current global outlook towards B5G/6G technologies development and may be used as a benchmark for later comparisons (in Deliverable D1.3). Given its relevance, a dedicated section on the European move towards telco cloud is included as well.
	Global Use cases Analysis	Section 2.2	An exhaustive analysis of the use cases investigated for 6G around the world was accomplished in D1.1. For this reason, the emphasis in this deliverable is on the European use cases prioritised at the 3GPP workshop in Rotterdam, one of the major outcomes of SNS ICE project in 2024; analysing the use cases and vertical sectors

			addressed in SNS Call 1 and Call 2 R&D projects to check its alignment with global trends, and provide some insights on replicability aspects.
	Mapping of EU and global KPIs	Section 2.2	Again, a detailed overview of global KPIs can be found in deliverable D.1. Here, instead we focus on the KPIs associated to the aforementioned European use cases prioritised at the 3GPP workshop in Rotterdam
	Standardisation planning and trends	Section 2.1	An updated analysis of the current standardisation roadmap for 6G networks for the consideration of SNS projects. The focus in on the analysis of the work conducted in selected WGs at 3GPP and ETSI.
	Analysis of Trials and Pilots in other regions	Section 2.2	This section also reports on selected trials and pilots being carried out at the global scale (US, Japan, Korea, China) and the corresponding industrial associations/funding programmes underpinning them. A number of commonalities and differences with the SNS-JU approach are identified.
Establish global dialogues & place SNS at a global Roadmap	SNS-ICE global ecosystem & road-mapping	Section 3.1 Section 3.2	Approach to create and enhance the SNS global ecosystem (current status, plans, etc.) as well as selected activities undertaken by SNS ICE/6G-IA towards the implementation of those MoUs.
	Make suggestions about future SNS R&I WPs	Section 3.3	An in-depth description of the contribution to future SNS R&I Work Programmes stemming from the stakeholders workshop on EU priorities carried out in April 2024, and in which SNS ICE played a major role.
	Identify trends and solutions promoted by other parts of the world not necessarily adopted by the SNS.	Section 3.2	In connection with Section 2.1, this part identifies the SNS plans to boost telco cloud activities which had been barely addressed to date, as well as a number of synergies with IPCEI-CIS and Cluster 4 programs in this telco-cloud area.
	Interaction with SNS projects and fine-tuning of SNS message	-	The SNS ICE approaches to interact and fine-tune received information from SNS projects, and to create the global SNS message were discussed in deliverable D1.1. They have been extensively used in the current reporting period but no specific section for those two aspects was deemed to be necessary in the current deliverable.
Organize international workshops and events	Organisation of international events, reporting and key takeaways and future plans	Section 4	List of events with international reach, that SNS ICE organised or participated in, reporting of status and next steps.

2 Monitoring and Analysis of EU & Global trends

2.1 Analysis of global B5G/6G trends and standardisation efforts

This section reports on and analyses several notable developments of 2024 in terms of B5G/6G trends and standards-related work. First, Section 2.1.1 focuses on world-wide priorities concerning technologies and KPIs. Specifically, this includes an outlook of the key drivers, features, and technologies needed for 6G; a succinct review of 6G KPIs; and an in-depth analysis of the contributions of SNS projects to 6G technologies and KPI definition following from the annual questionnaire that is circulated by the sister project SNS OPS among all the active SNS-JU projects. Next, Section 2.1.3 provides an update on global standardisation activities towards 6G being carried out at 3GPP's working groups RAN1 to RAN4 under the Technical Specification Group Radio Access Network (TSG RAN). It also includes recent work which is relevant for 6G in several industry specification and open source development groups at the European Telecommunications Standards Institute (ETSI), and other working groups at the International Telecommunications Union (ITU). This is nicely complemented by (i) an description of the pre-standardisation activities carried out under the umbrella of the 6G-IA; and (ii) a statistical analysis of SNS project contributions to such standardisation bodies.

2.1.1 Global 6G landscape analysis & world-wide priorities

A significant global survey has been performed by SNS ICE partners within this task, to identify the priorities of many major regions of the world in terms of targeted 6G KPIs, Use Cases and technological enablers and to compare them to the European priorities, trying to identify potential gaps in the EU research direction, and feeding this information as feedback for the design of the follow up SNS-JU work programmes.

This work aims to provide an aggregate, high-level view of the global 6G landscape based on the priorities, requirements, and vision expressed by key global stakeholders in various regions. The analysis focuses on three key areas: **i)** envisioned / prioritized 6G enabled Use Cases (Table 2), **ii)** key 6G enabling technologies (enablers) (Table 3) and **iii)** performance targets for the primary 6G Key Performance Indicators (KPIs) (Table 4) . The aggregated views of key stakeholders around the world offer unique cross-comparison capabilities, which in turn lead to significant insights regarding the commonalities and differences in 6G vision, the respective expectations around the world, and the prioritization of technologies and use cases in different regions of the world.

The information used for the analysis is sourced from publicly available documents that the various stakeholders, associations and regions have published, e.g., in the form of position or white papers, regarding their vision, priorities, and targets for the next generation of mobile networks. More specifically, the Networld Europe Strategic Research and Innovation Agenda (SRIA) [1], as updated in 2022, comprises one of the primary sources of the SNS-JU Work Programme for R&I projects and has been used to determine the EU technological directions. Two white papers from 5G Americas [3] and the Next G Alliance [4] have been used to determine the position of US stakeholders, while the Chinese priorities have been sourced from a Huawei white paper[5]. Similarly, extensive white papers have been used to determine the priorities of Japan [6], India [7][8] and Taiwan[9], while another extensive survey paper by S. Alraih et.al. [10], outlining the views of individual researchers around the world, has been used to compare region priorities to the latest research directions. Finally, the recently published ITU Recommendations on IMT-2030 [2] have been used to examine the proximity (or lack thereof) of the various regional priorities compared to the final ITU vision.

A first takeaway from the examination of Table 2 is that there is excellent coverage of all UCs across all stakeholders, as the matching table is heavily populated. This fact indicates the anticipation of next-generation networks, which promise to enable a substantial number of applications across the globe. Most stakeholders envision a broad portfolio of use cases supported by 6G as they address eight or more UCs (up to 13 for some).

Regarding specific UCs, some clear preferences emerge from observing Table 2, as certain UCs have been prioritized by almost all the stakeholders in this study, providing insights about the most anticipated UCs globally. Those UCs are: *Holographic Communications, Cyber-Physical Systems, Digital Twin, Manufacturing, Multi-*

Sensory xR, Gaming/Entertainment, Tactile/Haptic Communications, Medical/Health Vertical, Telesurgery, Cooperative Operation among a Group of Service Robots / drones. These UCs aggregate the interest of most stakeholders on a global scale, as they comprise the most challenging scenarios and applications envisioned that still cannot be supported by existing networks. Several of the above UCs are still in development and have not yet been applied in real-life scenarios. However, it has become clear that their stringent requirements will require significant improvements from next-generation networks.

A second group of UCs closely following the previously presented "prioritized group", that aggregated significant interest (6/8 or 5/8 matches) from the global stakeholders can be identified. Those UCs are Imaging and Sensing, Transportation UCs (automotive, logistics, aerial, marine, etc.), Space-Terrestrial integrated UCs, and Intelligent Operation Network. This second group is comprised of UCs focusing on specific vertical sectors, targeting applications with increased demands in terms of network performance and applications / services usually targeting specific network functionalities.

Finally, a third group of UCs is identified, which, although recognized as significant, do not seem to constitute priorities for most global stakeholders. Those UCs are Critical Infrastructure, Government/National Security, First Responder / Emergency Services, Smart Buildings and Agriculture / Smart Farming. These UCs remain highly relevant to the development of next-generation networks. However, they seem to attract a more localized interest, depending on the social needs, requirements, and cultural background of specific areas of the world. ITU also seems to prioritize eight specific UCs, mainly from the first group of UCs, which attract the interest of most global stakeholders.

Table 2: 6G Use Cases prioritized in various regions of the World.

6G Use Cases	Networld Europe SRIA 2022 [1]	5G Americas / Next G Alliance [3][4]	Huawei (China) [5]	B5G Consortium (Japan) [6]	TSDSI (India) [7][8]	MediaTek (Taiwan) [9]	Survey Paper [10]	ITU IMT-2030 [2]
Holographic Communications	√	√	√	√	√	√	√	√
Cyber-Physical Systems, Digital Twin, Manufacturing	√	√	√	√	√	√	√	√
Multi-Sensory xR, Gaming/Entertainment	√	√	√	√	√	√	√	√
Tactile/Haptic Communications	√	√	√	√	√	√		√
Medical/Health Vertical, Telesurgery	√	√	√	√	√	√	√	
Cooperative Operation among a Group of Service Robots / drones	√	√	√	√	√		√	√
Imaging and Sensing	√	√	√	√	√			√
Transportation Vertical (automotive, logistics, aerial, marine, etc.)	√	√	√	√	√		√	
Space-Terrestrial integrated network	√	√		√	√		√	√
Intelligent Operation Network	√		√		√		√	√
Critical Infra, Government/National Security	√	√		√				
First Responder/Emergency Services		√		√	√			
Smart Buildings			√	√	√			
Agriculture / Smart Farming				√	√			

In terms of key enabling technologies (enablers) that the various stakeholders believe to play a significant role in developing the next-generation networks to support the desired use cases and their demanding requirements, Table 3 presents the overview. A total of 14 enabling technologies were identified from the source material. It is interesting to note that once again, an extensive coverage of these enablers is observed, as most stakeholders identify ten or more of these enablers as necessary for the development of 6G networks. This broad coverage showcases the expectation that many technologies are required to deliver on the global vision of 6G and enable the targeted use cases. With regards to the prioritization of these technologies on a global scale, a large group of enablers is clearly aggregating the interest of most stakeholders (8/8 or 7/8 matches), namely: *AI related enablers (Edge, RAN, AIaaS), Cloud Native Network and RAN-Core Convergence, mmWave and THz Radio, Communications and Sensing co-design (ISAC), Spectrum Migration, Integrated Satellite hybrid infrastructures (NTN), New Antenna Technologies (e.g., RIS), Trustworthiness / Multilateral trust architecture*.

The common belief across the globe that these enablers are the key to the development of 6G networks showcases the importance of these technologies and explains the interest of the global research community on these hot R&D topics. Another testament of the global consensus around these enabling technologies is the fact that the ITU recommendations document [2] directly references all of them, as the key enablers considered for IMT-2030 (except for spectrum migration, which is implicitly addressed, as it is handled by the World Radiocommunication Conference).

Table 3: 6G Enabling Technologies considered in various regions of the World.

Enabling Technologies	Networld Europe SRIA 2022 [1]	5G Americas / Next G Alliance [3][4]	Huawei (China) [5]	B5G Consortium (Japan) [6]	TSDSI (India) [7][8]	MediaTek (Taiwan) [9]	Survey Paper [10]	ITU IMT-2030 [2]
Artificial Intelligence at the Network Edge	√	√	√	√		√	√	√
AI/ML in the RAN	√	√	√	√	√	√	√	√
AI as a Service: Data / network autonomous management	√		√	√	√	√	√	√
Fully Service Based – Cloud Native Networking and RAN-Core Convergence	√	√	√	√	√	√		√
mmWave and THz Radio	√	√	√	√	√	√	√	√
Communications and Sensing co-design (ISAC)	√	√	√	√	√	√	√	√
Spectrum Migration	√	√	√	√	√	√	√	
Integrated Satellite hybrid infrastructures (NTN)	√	√	√	√	√	√	√	√
New Antenna Technologies (RIS)	√	√	√	√		√	√	√
Trustworthiness / Multilateral trust architecture		√	√	√	√	√		√
Deep Edge, Terminal and IoT device integration	√				√	√		
Optical Wireless communication	√			√	√		√	√
Blockchain	√			√	√		√	
Quantum Computing				√	√	√	√	

Finally, the analysis of the expected performance of 6G networks focuses on eight main technical KPIs is presented in Table 4 and provides a well-rounded view of the expectations of the various stakeholders. By observing the data, it becomes clear that even though the various stakeholders come from different backgrounds with potentially different visions of what 6G networks should accomplish, their requirements in terms of performance appear to be well aligned. Even though minor differences can be detected for certain KPIs, the overall "big picture" points towards an aligned view for these main KPIs. Moreover, the KPI targets of the regional associations and stakeholders also align well with the prevalent scientific views available in the literature [10]. Interestingly enough, some differences can be detected between the regional targets and the adopted values from ITU [2], which seems to have opted for a more conservative approach regarding certain KPIs such as the peak data rate, the user data rate, and positioning accuracy.

Regarding peak data rates, most stakeholders seem to agree that a value of up to 1 Tbps should be targeted, except for the B5G Consortium, which adopted a more modest target of up to 200 Gbps. Notably, ITU has adopted the same value for the IMT-2030 recommendations. On the other hand, two distinct groups can be observed in terms of targeted user data rates, i.e., the more ambitious group (EU, Huawei, B5G Consortium, TSDSI) that has set a target of 10 Gbps or even up to 100 Gbps, while the more modest group (US, Taiwan, Survey paper) has set a target of around 1 Gbps. In this case, the target adopted by ITU is even lower than the modest target, aiming for a user data rate of 300-500 Mbps.

Even though some differences were detected in targeted data rates, there seems to be almost exact alignment among the global stakeholders for the other main KPIs, namely density, reliability, and user-plane latency. All stakeholders, including the research community, agree that a 10 million devices/km2 target is suitable for 6G. In comparison, the ITU treats this value as a minimum with an even more ambitious goal in mind (108 devices/km2). In terms of reliability, expressed in targeted Block Error Rate (BLER), there is also an alignment as all stakeholders propose values between 10-7 – 10-9. In this case, the ITU adopts a more modest target again, treating the 10-7 target, as the best-case scenario. Almost all stakeholders share similar targets for user-plane latency where values between 0.1-1 ms seem to be commonly desirable, except Taiwan, targeting a more modest performance of 0.5-5 ms. In this case, the ITU recommendation agrees with most stakeholders, targeting values of 0.1-1 ms.

Even though it is commonly agreed that energy efficiency is one of the primary goals of 6G, several different definitions and approaches can be found in the literature. A significant number of global stakeholders attempt to approach this KPI in terms of expected improvement with respect to the energy efficiency of 5G, where three stakeholders (Huawei, B5G Consortium, Survey paper) seem to consider a value of 100x with respect to 5G as the most appropriate. However different values are also mentioned, while some stakeholders don’t provide any specific value for this KPI. In a similar approach, ITU has not provided a specific target value for energy efficiency in the IMT 2030 recommendations.

Finally, an alignment of views can also be observed regarding mobility and positioning accuracy. In terms of mobility, all stakeholders agree that a target of supporting mobility up to 1000 km/h is appropriate for 6G networks, which is also the target set by ITU. The stakeholders’ commonly accepted target for positioning accuracy is around 1 cm, with some variations mentioned per region, while once again the ITU treats this as the best-case scenario, targeting values of 1-10 cm.

It is worth noting that the network improvements in terms of KPIs usually come with a cost (complexity of equipment, additional spectrum needed, increased energy consumption etc.). This is why it is essential not only to set ambitious targets for every generation of networks but also to have a clear reasoning if the targeted use cases need these improvements

Table 4: 6G KPI Targets in various regions of the World.

KPIs	Networld Europe SRIA 2022 [1]	5G Americas / Next G Alliance [3][4]	Huawei (China) [5]	B5G Consortium (Japan) [6]	TSDSI (India) [7][8]	MediaTek (Taiwan) [9]	Survey Paper [10]	ITU IMT-2030 [2]
Peak Data Rate	1 Tb/s	0.5-1 Tbps	1 Tbps	100-200 Gbps	0.5-1 Tbps	1 Tbps	1 Tbps	50-200 Gbps
User Data Rate	10 Gbps	DL: up to 1 Gbps UL: up to 1 Gbps	10-100 Gbps	10-100 Gbps	DL: up to 10 Gbps UL: up to 5 Gbps	> 1 Gbps	1 Gbps	300-500 Mbps
Density	10^6 devices/km2	10^6 devices/km2	10^6 devices/km2	10^6 devices/km2	10^6 devices/km2	n/a	10^6 devices/km2	10^6 - 10^8 devices/km2
Reliability [BLER]	>1-10-8	>1-10-8	>1-10-7	>1-10-7	>1-10-7	n/a	>1-10-9	~1-10-5 - 1-10-7
U-Plane Latency	<0.1 ms	0.1-1 ms	0.1 ms	0.1-1 ms	0.1-1 ms	0.5-5 ms	0.01-0.1 ms	0.1-1 ms
Energy Efficiency (Network/ Terminal)	>100% gain vs IMT-2020	Extremely low power / never charging devices	Network: 100x w.r.t 5G Device: 20 years battery	Network: 100x w.r.t 5G	Battery life-time up to 20 years	n/a	Network: 100x w.r.t 5G	n/a
Mobility	<1000 Km/h	> 500 km/h	n/a	Up to 1000 km/h	Up to 1000 km/h	n/a	Up to 1000 km/h	500 - 1000 km/h
Positioning accuracy	<1 cm	1 mm - 10 cm Six degrees of motion: (x,y,z)	Outdoor: 50 cm Indoor: 1 cm	1-2 cm	< 1 cm	n/a	1 cm	1-10 cm

This analytical study, also resulted in a conference paper (EuCNC & 6G Summit 2024), while extensive results along with an analysis of the global standardization roadmaps and timelines are also presented in deliverable D1.1 [11].

2.1.2 Analysis of the contributions of SNS projects to 6G technologies and KPI definition

Besides analysing the global technological and KPI trends, it is also extremely important to look inward and to obtain a good high-level view of the technologies, and targets that the SNS-JU projects are working on. This allows for a comparison of the SNS trends versus the rest of the world and an estimation of the alignment or differentiation in terms of 6G research directions. In order to do that, the SNS ICE has cooperated with the4 SNS OPS CSA, in order to obtain a good overview of what the SNS projects are working on.

The SNS OPS CSA project, is tasked with monitoring the work, achievements and insights of the SNS-JU R&I projects, in order to maintain a good overview of the addressed technical, vision and market issues within SNS-JU and to aggregate information regarding the most important findings and insights. SNS OPS achieves this via an annual questionnaire which is circulated to all the active SNS-JU projects as part of their Monitoring and Analysis Framework, described in the SNS OPS deliverable D1.1. SNS ICE has aligned with SNS OPS and has contributed some of the questions that are included in the questionnaire and is also granted access to the detailed results of the responses analysis, in order to be aware of the key activities and achievements within SNS-JU and to be able to promote them on the EU, vertical and global stage.

So far, two editions of the questionnaire have been completed by the active SNSJU projects. The first one was issued in 2023 and addressed the first 35 Call 1 projects of the NSS JU (the detailed analysis of their responses can be found in the SNS OPS deliverable D1.2, while the insights of the analysis were presented to the SNS

community via a webinar[1] on November 2023), while the 2nd one addressed both Call 1 and Call 2 projects (63 projects in total) and the gained insights were presented to the SNS community during another webinar[2] on June 2024 (the detailed analysis will be delivered in the SNS OPS deliverable D1.4 due at the end of 2024).

In order to understand the alignment of the SNS projects vision and work with the rest of the global regions and EU and vertical associations, it is important to examine the technologies and the KPIs addressed by the SNS-JU projects, as depicted by Figure 2 and Figure 3 respectively (based on the 2nd SNS OPS survey[24]). From the below analysis one can observe that the majority of SNS projects are working on the development of AI/ML solutions for the next generation networks and on system architecture and control issues, which is not surprising as we are still going through the early phases of development of the 6G networks. Other popular technological topics include edge/ubiquitous computing, advanced radio technologies such as millimeter waves and Terahertz communications, service resource management, ISAC and Energy Efficiency solutions. The main take-aways from the analysis of Figure 2, is that the work carried out by the SNS projects in terms of technological topics is well aligned with the global interests and work, as they address some of the most prominent and promising technologies for 6G, while at the same time ensuring that the SNS-JU is not left behind in other technological sectors, as a multitude of technologies are being investigated (more than 22).

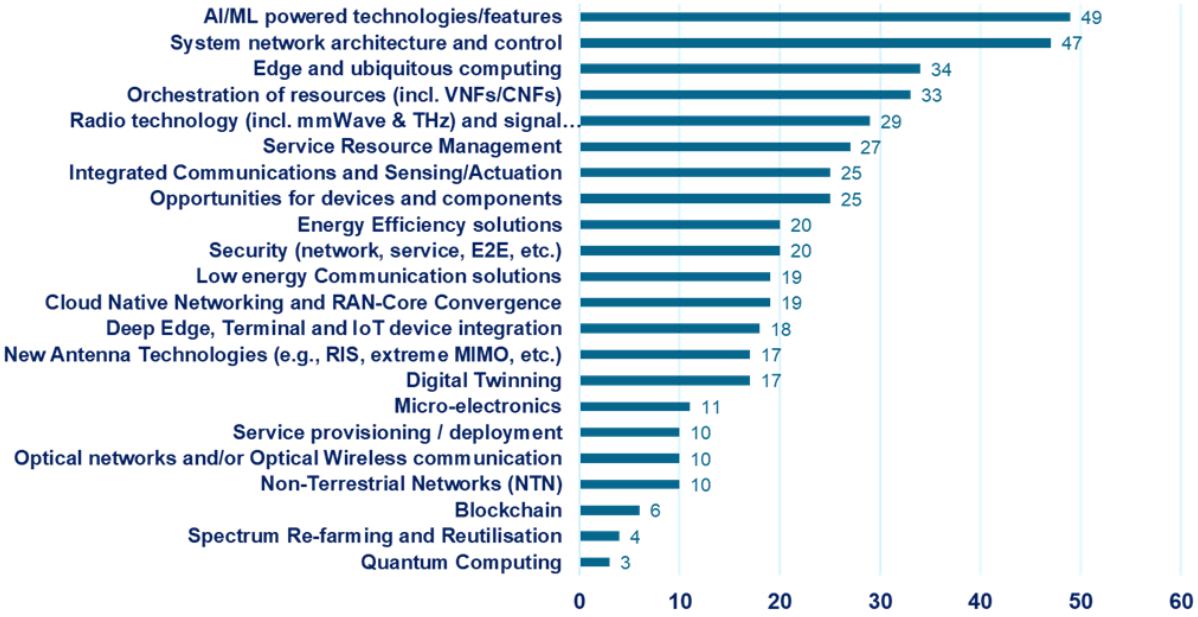

Figure 2: Technological issues / aspects addressed by SNS Call1 & Call 2 projects[3].

Finally, by taking a look at Figure 3 and the KPIs targeted by the SNSJU projects, a significant alignment can be observed with the rest of the national and global initiatives, as Energy Efficiency is regarded as one of the most important metrics of success for 6G, while latency and reliability follow next, as most of eMBB services are rather well covered already by (B)5G, and hence further development of that aspect, while always relevant, is not the most anticipated one.

[1] https://smart-networks.europa.eu/event/sns-ops-survey-webinar/
[2] https://smart-networks.europa.eu/event/sns-ops-questionnaire-results-webinar/
[3] Based on the SNS OPS survey of 2024

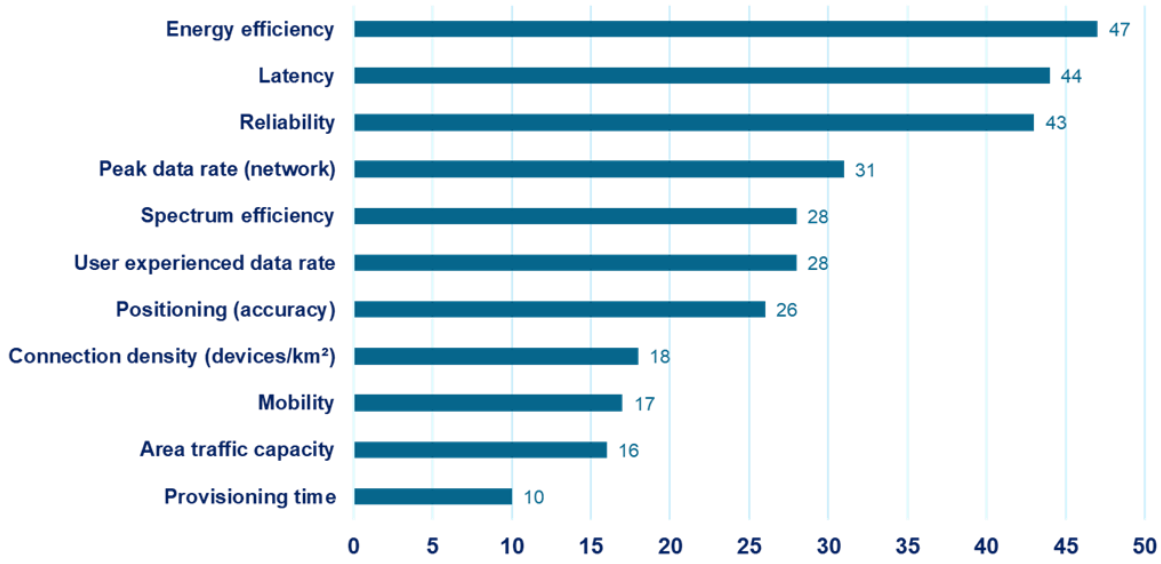

Figure 3: KPIs addressed by SNS Call1 & Call 2 projects[25].

2.1.3 Update on global standardisation activities

In 2024, significant progress has been made in aligning European ICT and communication standards with policy goals, enhancing Europe's influence in global 5G and 6G standardisation. Europe's active contributions, especially in developing intellectual property for network standards, remain essential for maintaining a competitive edge. Cross-sector collaboration has expanded, with manufacturers, operators, and public institutions working toward shared 6G objectives that reinforce Europe's standing in the global ecosystem.

Direct engagement between European organisations, key standardisation bodies like ITU, ETSI, and 3GPP, and the private sector has been central to consolidating both regional and international standardisation efforts. These collaborative initiatives have helped strengthen interoperability, competitiveness, and technological sovereignty, supporting Europe's role as a leader in the evolving global standardisation landscape.

2.1.3.1 Recent activities at 3GPP towards 6G

3GPP's roadmap has seen activity in 2024, marking advances in both 5G and preparatory steps for 6G. In September 2024, 3GPP SA1 6G planning update was given. It contained two important items: the next large 3GPP workshop and second the timeline of Release 21 (6G) / IMT2030 submission.

Figure 4: Update 6G 3GPP timeline.

As a major follow-up to the Stage 1 workshop in Rotterdam (a more detailed report can be found in Section 2.2.2), a Technical Specification Group (TSG) wide workshop is planned in March 10th and 11th in 2025. The setup is A) separate Parallel TSG RAN and TSG SA sessions B) at the beginning and end a Joint RAN/SA/CT session. In this workshop 3GPP members can contribute on System / CN aspects, 6G stage-2 study organisation. For European research it is important to note that only one contribution per company or **Market** Representation Partner (MRP) /Vertical is accepted, so collaboration is important to achieve impact in this 3GPP workshop.

After this workshop, technical studies on the 6G radio interface and 6G core network architecture will start in June 2025, both within the RAN and SA Working Group. Making the workshop more important, as the work will be aligned towards the outcomes of the workshop.

Regarding the 6G timeline and IMT2030 submission, Release 21 is designed to deliver the first 6G technical specifications and expected to be delivered in a single drop for IMT submission before 2030. The timeline of this important release will be decided upon no later than June 2026, but an important note is made that ASN.1 / OpenAPI freeze (important interfaces of 6G networks) will not be earlier than March 2029. This timeline provides a structured path for 6G, ensuring a gradual, well-supported transition from 5G to 6G capabilities.

In the meantime, most of the work being carried out in the various WGs focuses on 5G advanced technologies that will pave the way towards 6G systems. Specifically, early in the year, Release 18 was finalised, marking the launch of 5G Advanced, which introduces enhancements to the existing 5G framework and broadens the capabilities of 5G networks. This release integrates refinements based on commercial 5G network insights, supporting advanced features like improved energy efficiency, more robust network slicing, and capabilities targeting vertical industries. It lays a foundation for upcoming 6G standards by supporting new market segments and use cases within the 5G ecosystem.[4] Following the completion of Release 18, Release 19 is currently in progress and expected to be completed by late 2024. Release 19 builds upon 5G Advanced by exploring higher-bandwidth applications and improving the handling of ultra-reliable low-latency communications (URLLC), key components for autonomous vehicles, smart manufacturing, and other advanced use cases. This release further enhances machine-type communications and network intelligence, expanding 5G's applicability across various industries and setting the stage for subsequent releases.[5] Looking forward, Release 20 will likely see completion in late 2025. Release 20 is expected to serve as a bridge between 5G Advanced and early 6G concepts, focusing on incorporating more extensive artificial intelligence (AI) capabilities and enabling even more advanced use cases in IoT and network automation.

Focusing on the radio access network, the 3GPP RAN Working Groups convened in Melbourne for their 105th plenary meeting, mainly dealing on advancing activities for Rel-18, Rel-19, and the early stages of Rel-20. Overall, the RAN Working Groups made progress in advancing key areas across multiple releases. RAN1 focused on physical layer enhancements for MIMO, wake-up signals, and XR applications. RAN2 delved into AI/ML integration, mobility improvements, and energy-saving measures. RAN3 prioritised architectural refinements for NG-RAN and multimodality support, while RAN4 drove advancements in performance testing and consistency across features. The paragraphs below provide a detailed account of the discussions and progress, categorised by the specific RAN groups.

RAN1 (Physical Layer)

RAN1 concentrated on refining key physical layer aspects of Rel-19 and completing outstanding Rel-18 tasks. In the area of MIMO, normative work progressed on enhancements for SRS port grouping in TDD systems, enabling low-complexity 6RX and 8RX receivers, along with support for antenna switching capabilities. RAN1 also continued its study of non-codebook-based uplink transmission methods to improve flexibility and efficiency. Discussions on Rel-19 Low-Power Wake-Up Signals (LP-WUS) included expanding the scope to cover FR2 bands,

[4] https://www.5gworldpro.com/blog/2024/06/20/major-milestone-in-5g-evolution-3gpp-release-18-finalized/.
[5] https://www.3gpp.org/technologies/ran-r18-r19

emphasising design reuse and ensuring compatibility with existing configurations. Work also focused on XR applications, where new uplink scheduling techniques were developed to enhance capacity and meet delay-sensitive requirements. Multi-carrier scheduling was another priority, with progress on supporting PUSCH and PDSCH scheduling for multiple cells with varying subcarrier spacings, demonstrating the group's commitment to enhancing NR flexibility and performance.

RAN2 (Layer 2 and Radio Resource Management)

RAN2 advanced several initiatives related to Rel-19, particularly in artificial intelligence and machine learning (AI/ML). Efforts included evaluating the impact of AI/ML on mobility management and resource management, while ensuring alignment with other groups, such as RAN4, to maintain consistency. Studies on Ambient IoT focused on clarifying out-of-coverage operational aspects and examining carrier-wave interference characteristics, with further discussions scheduled for late 2024. Mobility enhancements were a significant focus, as RAN2 worked on refining CSI acquisition and reporting methods to improve handover efficiency and network performance. The group also tackled uplink congestion signalling, specifying methods for dynamic indication in downlink signalling to enable more responsive network management. Energy-saving initiatives, particularly those related to on-demand SIB1 configurations for Network Energy Saving (NES), were further developed, reflecting the group's broader commitment to sustainability.

RAN3 (Architecture and Interfaces)

RAN3 continued its pivotal work on NR architecture and interfaces, particularly in AI/ML for NG-RAN. The group explored data collection enhancements within the NG-RAN framework to support advanced use cases such as mobility optimisation and network slicing. Rel-19 topological enhancements received attention, with RAN3 specifying support for wireless access backhaul and femto architectures. This included refining operational modes for femto access points and ensuring compatibility with closed, hybrid, and open configurations. The group also addressed multimodality support for XR applications, exploring uplink and downlink solutions while aligning with outputs from SA2. These efforts demonstrate RAN3's focus on ensuring robust, scalable architectures that align with evolving use cases.

RAN4 (Performance and RF Requirements)

RAN4 concentrated on finalizing Rel-18, with performance-related work on NR positioning being the only remaining task, targeted for completion by June 2024. The group also worked on testing and evaluation for Rel-19 features, including beam management and over-the-air (OTA) testing methodologies for FR2 bands. AI/ML-related efforts focused on ensuring testability and interoperability, with particular attention to mobility scenarios and beam management strategies. RAN4 initiated work on consistency in training and inference for CSI compression and prediction, setting the stage for normative efforts beginning in early 2025. These studies aim to establish a solid foundation for advanced network performance in both the near and long term.

2.1.3.2 Recent activities in ETSI towards 6G

The European Telecommunications Standards Institute (ETSI) members is only one of the three bodies recognised by EU as European Standards Organisation with members foremost concentrated in Europe. This organisation has five industry standardisation groups (ISG) relevant for members to coordinate their 5G/6G research pre-standard: ETSI ISG Zero touch network & Service Management (ZSM), ISG Terahertz (THz), ISG Experiential Networked intelligence (ENI), ISG Integrated Sensing and Communication (ISAC) and ISG Reconfigurable Intelligent Surfaces (RIS). To further support 6G, ETSI has developed open-source projects that include TeraFlowSDN for software-defined network control, OpenSlice for network-as-a-service support, and OpenCAPIF for secure API access. These initiatives, supported by several European projects, aim to build a comprehensive toolkit for advanced network deployment and management. Besides, several related groups are of interest towards 6G: Research, Innovation and Standards Ecosystem (RISE) group as well as the ETSI

Technology Radar (ETR) for Integrated Sensing and Communication. An overview of the scope of those groups along with recent developments and achievements in 2024 are provided in subsequent paragraphs.

ETSI ISG Zero touch network & Service Management[6] (ZSM)

The industry group Zero touch network & service management dates back already to 2017. For obvious reasons, it focuses on provisioning of any network, not only 6G. The key of many services is to provision it over different networks in a very efficient manner. Given the higher complexity of 6G networks and services cost additional challenges are introduced for the provisioning.

In 2024, three work items have been formally adopted by the ISG, this including a study on the utilisation of agents in autonomous networks, and a ZSM Framework for NaaS. In addition, the group has produced a study on network digital twins for enhanced ZSM (GS ZSM 018), in final draft form, as well as two early drafts on community level assessment security, and CI/CD (Continuous Integration/Development) automation.

ISG Experiential Networked intelligence[7] (ENI)

Experiential Networked intelligence relates to ISG ZSM, but it is foremost network oriented and seeks similar control over complexity and more adaptive networks. In 2024, it has delivered a first proposal on how network is capable of adapting to the user intent, translation to precise network strategies and detect potential conflicts_ "ENI: Definition, Requirements and Procedure of Intent Policy Multi-Stage Translating & Conflicts.

ISG Terahertz[8] (THz)

The scope of this group includes channel measurement and modelling aspects. Besides, a clear link is leveraged by the group to advances in semiconductors and new materials with three fabrication approaches: electronics photonics, plasmonic. The industry group of Terahertz has contributed in 2024 to two important challenges: frequency identification and use cases. Specifically, two group reports were formally approved in November 2024 entitled "Channel measurements and modeling in THz bands" (GR THz 003), and "RF Hardware Modeling" (GR THz 004). Prior to that, the fifth face to face meeting of the ISG THz was held in March in Oslo at Telenor headquarters. The meeting was attended by 29 participants representing 19 companies and institutions.

ISG Integrated Sensing and Communication[9] (ISAC)

The ISG is working on pre-standards research for integrated sensing and communication (ISAC) to prepare for 6G. Its objectives include defining key 6G use cases, including intruder detection and environmental monitoring, which expand 6G's capabilities beyond traditional communication; developing advanced channel models, setting KPIs, and evaluating system architectures. This work, coordinated with European and global initiatives, supports future 6G releases from 3GPP and ITU-R's IMT-2030 goals, also addressing privacy, security, and sustainability in line with UN objectives.

The first three deliverables are planned for 2024, on use cases, channel modeling and architecture. Specifically, the group reports, in early draft form at the time of writing these lines, are entitled "ISAC Use Cases and Deployment Scenarios" (GR ISC 001), "ISAC Channel Modeling, Measurements and Evaluation Methodology" (GR ISC 002), and "System and RAN Architectures for ISAC" (GR ISC 003). A plenary meeting of the ISG is scheduled in December, in Munich.

[6] https://www.etsi.org/committee/zsm
[7] https://www.etsi.org/committee/eni
[8] https://www.etsi.org/committee/2124-thz
[9] https://www.etsi.org/committee/2295-isac

ISG Reconfigurable Intelligent Surfaces[10] (RIS)

Reconfigurable Intelligent Surfaces workgroup identifies use cases, deployment and requirements. Subsequently the technology are identified in a wide area e.g., in fixed, mobile, sensing, EMF exposure limits, security and privacy. Deliverables have already been published in 2023 on architecture, channels and use cases and an update of these documents will come early 2025. Notably, in 2024 the ISG has produce a final draft of the group report "Implementation and Practical Considerations" (GR RIS 004).

SDG TeraFlowSDN[11] (TFS)

TeraFlowSDN develops an open-source cloud native SDN Controller enabling smart connectivity services for future networks beyond 5G. Their work falls under the scope of several standards groups this including IETF, ISG MEC, ZSM, mWT, NFV, QKD, F5G, TC SAI.

In 2024, TFS released two versions of its TeraFlowSDN, the Software-Defined Networking (SDN) controller developed by the software development group. Release 3, launched in April 2024, introduced enhanced capabilities, including the integration of an Optical SDN controller, advanced network orchestration features such as IP over DWDM, L3VPN, and MEC, and improved network topology exposure with a new BGP-LS speaker and a Forecaster component. Release 4, unveiled in November 2024, delivered a comprehensive set of features, including integration with Quantum Key Distribution (QKD), end-to-end network automation and monitoring, and substantial advancements in network management, optical networks, security, and blockchain integration.

SDG OpenSlice[12] (OSL)

OpenSlice develops an open-source Operations Support System to deliver Network as a Service. Their work is related and has connections with other associations and standard development groups such as GSMA, TM Forum, 3GPP, ISG ZSM, NFV, to name a few.

In July 2024, OSL OpenSlice made publicly available its 2024Q2 release. This latest release provides cloud native support so that it can be deployed via docker compose and HELM Chart. It also offers native Kubernetes support, enhanced NFVO primitive support, and the transition of service characteristics between related services underwent a major revision to properly reflect and isolate customer and resource facing aspects. In addition, the SDG demonstrated the synergies between OSL and Sylva to optimize service orchestration and resource management for telecom operators. This was showcased at the Software and Standards for Smart Networks and Services (SNS4SNS) Conference which was co-organised by ETSI and the 6G-IA.

SDG OpenCAPIF[13] (OCF)

OpenCAPIF (OCF) develops an open-source Common API Framework as defined by 3GPP to enable API exposure and invoke in a secure and consistent manner. Other SDOs and standards groups in scope include 3GPP, ISG MEC, ZSM, NFV, among others.

The kick-off of the group took place in Madrid, on January 18, 2024. In July, the group announced the first release of SDG OpenCAPIF. This new version introduces several improvements and new features to deliver a more robust, secure, and efficient API Management Platform. These advancements are developed in tight collaboration and incorporating feedback from a growing research ecosystem including SNS projects such as 6G-SANDBOX, FIDAL, IMAGINEB5G, SAFE6G, ORIGAMI, ENVELOPE and SUNRISE6G.

[10] https://www.etsi.org/committee/ris
[11] https://tfs.etsi.org/
[12] https://osl.etsi.org/
[13] https://ocf.etsi.org/

2.1.3.3 Recent activities at ITU on 6G

In parallel, the ITU's IMT-2030 framework has made advancements, defining requirements and guidelines for 6G. In 2024, the ITU Radiocommunication Assembly refined the IMT-2030 framework, focusing on the essential criteria for 6G radio interface technologies (RIT). This framework emphasizes expanded, seamless connectivity and aims to support next-generation applications that require enhanced bandwidth, ultra-low latency, and extensive device connectivity. Following the 2023 approval of the IMT-2030 framework, ITU is now working on establishing detailed requirements for 6G technologies and setting evaluation benchmarks. Between 2024 and 2027, ITU will refine these specifications further, supporting immersive applications, enhanced ubiquitous coverage, and intelligent network capabilities. These developments cater to both urban and remote areas, addressing diverse global connectivity needs and preparing for widespread 6G deployment. To promote industry adoption, the IMT-2030 framework also emphasizes sustainable connectivity solutions, addressing increased energy efficiency and promoting green technology in telecommunications. Through these measures, ITU aims to position 6G as a transformative force across sectors, enabling advanced applications like smart cities, autonomous transportation, and immersive experiences that require high-speed, low-latency connectivity. These coordinated 3GPP and ITU developments provide a cohesive approach to the next phase of wireless technology, setting a solid groundwork for the transition from 5G to 6G in the coming decade.[14]

2.1.3.4 Pre-standardisation activities in the 6G-IA

Meanwhile, **6G-IA's Pre-Standardisation Working Group** continues monitoring trends and updates across the SNS-JU projects community to align 5G and 6G efforts with regulatory bodies such as ETSI, 3GPP, and ITU-R. This approach supports a unified European strategy for future standardisation, preparing the foundation for seamless 6G adoption in the coming years.

In 2024, standards-related activities in the SNS-JU have been reinforced through the creation of a new sub-working group within the **SNS-JU Policy Working Group**. The Policy WG contributes to shaping European policies, including strategies, roadmaps and recommendations relating to Smart Networks & Services technological, societal and industrial competitiveness aspects. Its primary purpose is to support the definition of policies that should be implemented in strategic technological, societal, and industrial areas by capturing the priorities and needs of the European industry, academia, and other relevant stakeholders by directly advising the SNS-JU Governing Board. The SNS-JU Policy Working Group, being a strategic one, is co-chaired by the public (EC) and the private (6G-IA) sides. Membership is by invitation only. The SNS-JU Policy WG consists of two subgroups, namely, the Connected, Collaborative Computing (3G), and the standardisation activities sub-WG.

The mandate of the **standardisation activities subgroup** is to discuss standardisation, in particular how to further streamline the priorities on use cases for 3GPP to maximize support in standardisation, this including policy issues such as security, sustainability, EU strategic autonomy and others. Potential topics for discussion under the umbrella of this sub-WG include the current and emerging trends in the telecom industry, with a view to assessing their implications on the SNS-JU Work Programme. The standardisation sub-WG kickstarted its activities on October 9, 2024 with a very broad support of the various stakeholders involved. To ignite discussions, participants were asked to provide their views on the main standardisation priorities from the private side, the key Standards Development Organisations (SDO) to be targeted for standardisation, opportunities in 3GPP/ETSI and SNS for SNS-related topics, the main priorities from the public side, etc. A schedule of bi-weekly meetings is planned for this WG. Immediate next steps included the preparation of a short list of areas where streamlining among European stakeholders could be possible (e.g., Sustainability, use cases, 6G lean architecture, Telco cloud, northbound interfaces, etc.); and the analysis of the current landscape with the use of tools (e.g., IPlytics) to explore current status (e.g., on SEP), among others.

[14] More information available here https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2030/Pages/default.aspx.

2.1.3.5 Analysis of contributions of SNS projects to standardisation bodies

According to the survey to SNS projects run by SNS OPS and as shown in Figure 5 below, ETSI and 3GPP continue to be the most popular standardisation bodies for contributions for Call 1 and 2 projects. Interestingly, an increase can be observed in the contributions to O-RAN at the expense of those to the Internet Engineering Task Force (IETF)/ Internet Research Task Force IRTF.

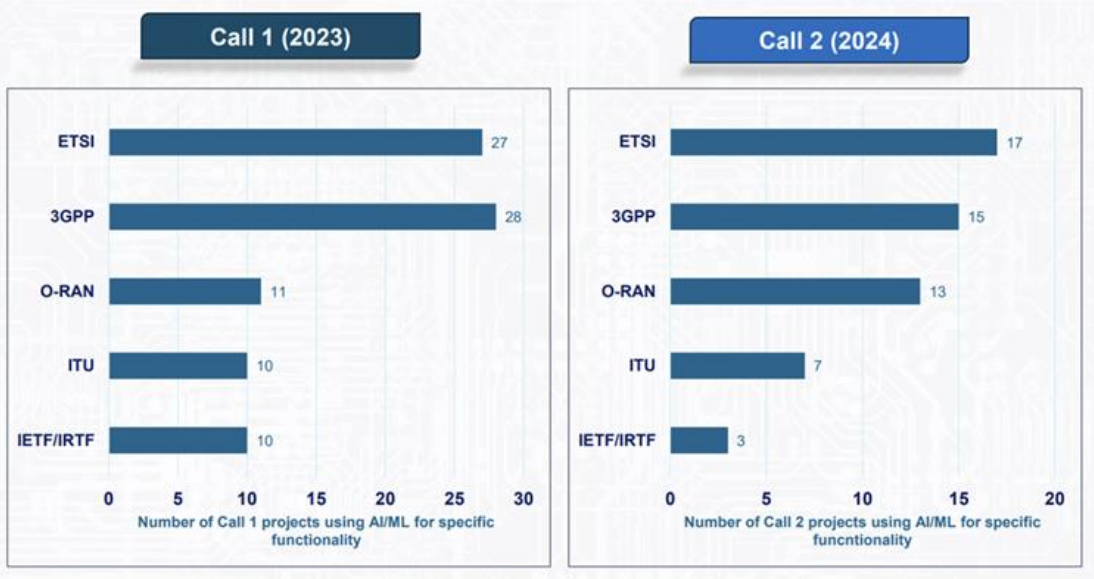

Figure 5: Contribution projects to standard bodies.

Figure 6 below provides further details on the standardisation and specification groups mainly targeted by SNS projects. Clearly, the majority of 3GPP contributions are aimed at System Architecture (SA2) specification group which can be explained given the 3GPP timeline and the planned workshop in March 2025 which will focus on core network and system aspects. The high number of contributions to O-RAN Radio Intelligent Controller Workgroup (WG3 and WG2) and ETSI Zero-touch network and Service Management (ISG ZSM) can be similarly explained, as they strongly relate to system aspects at this stage.

Figure 6: Projects aimed contribution to standards in call 2.

Finally, Figure 7 illustrates the evolution in open-source contributions by SNS projects, both to working groups in standardisation bodies and open-source projects. The total number has substantially increased: from only 23 in Call 1, to 67 open-source contributions in Call 2 projects. Most of these contributions, 28, are geared towards

radio access networks (Open-RAN, OpenAirInterface, SRSRAN). In the first call 1, in total 132 open-source solutions have been used. The top-ranked open-source solutions which projects made use of are: in the core (e.g. Open5GS, FreeGC, ..), cloud (Cubernetes, Docker, ..), followed my smaller areas Radio, Support Systems.

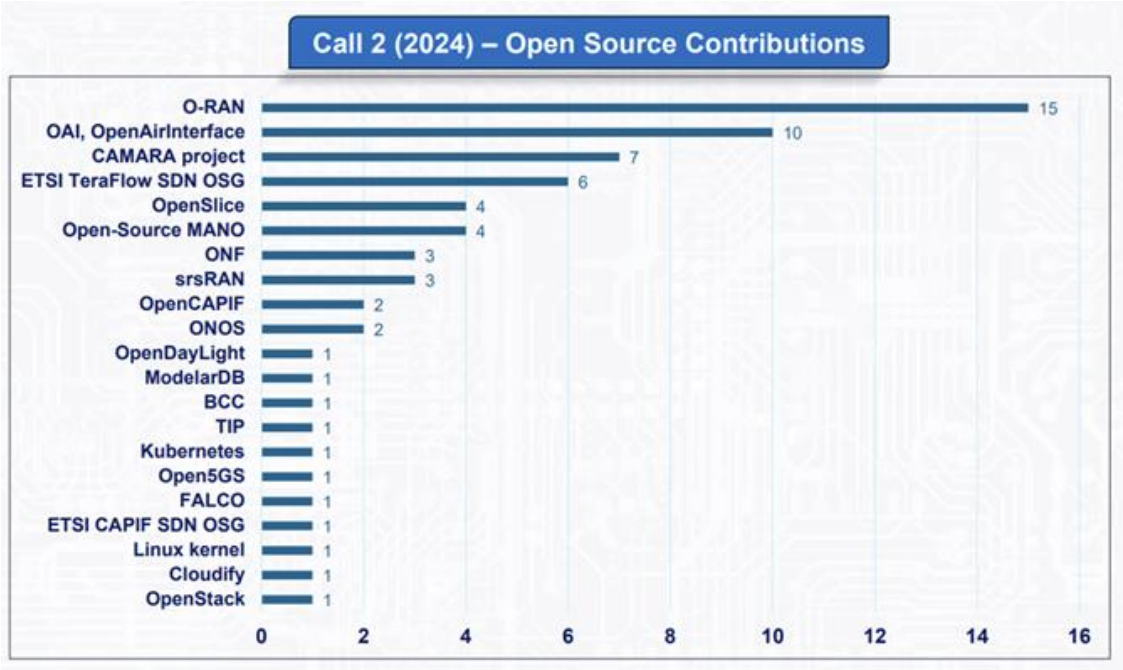

Figure 7: Open-source contributions from Call 2 projects.

2.1.4 The European move towards telco cloud

Telco cloud solutions and streamlined service deployment will be of prime importance for the European telecom industry. The current situation is not favourable for Europe. Hyperscalers currently dominate the cloud market. Due to the cloudification of the networks and the lack of standardised European alternatives, the operators rely on proprietary cloud solutions provided either by hyperscalers or based on their own developments. This is placing European operators at risk of dependency and vendor lock-in. This may lead to some negative impact on the European mobile operators that could subsequently affect the vendors and the overall European telco and service provision ecosystem.

As cloudification is further progressing towards the edge and the RAN, if the current situation continues, there is a strong possibility that the European telecommunication market, as we know it today, will cease to exist. On the positive side, the operators have some competitive advantages i.e., a) the "ownership" of the spectrum and b) a large number of sites that can be used to deploy edge-clouds that will help them offer more competitive solutions (e.g., in terms of lower latencies). If designed properly, this further disaggregation of cloud facilities may alter the existing business models favouring the European stakeholders.

Recognizing the importance of this technological area for Europe, the EC has recently published a white paper on "How to master Europe's digital infrastructure needs?" [35]. Under Pillar One of this white paper, the EC indicates its strong interest in large-scale pilots that will set up end-to-end integrated infrastructures and platforms for telco cloud and edge and the possibility of creating infrastructure-focused IPCEI. Also, it is worth noting that the IPCEI-CIS ("Important Project of Common European Interest on Next Generation Cloud Infrastructure and Services" [15]) is a significant EU initiative aimed at enhancing Europe's cloud and edge computing capabilities. Launched by the European Commission, IPCEI-CIS promotes the development of secure,

[15] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6246

decentralised cloud solutions with a strong focus on energy efficiency and data sovereignty. It involves various European companies and research institutions working to create an interoperable cloud-edge framework, which includes developing open-source software to facilitate real-time, low-latency data processing close to users. This initiative is expected to have wide-ranging impacts, including supporting Europe's digital and green transitions, enhancing data privacy, and boosting competitiveness within the EU cloud infrastructure ecosystem. By supporting innovative projects under IPCEI-CIS, the EU aims to reduce dependence on non-European hyperscalers while promoting technological sovereignty. The project will be implemented over several phases through 2031, with an open-source infrastructure anticipated by 2027.

At the same time, in Horizon Europe Cluster 4 EC plans for a call for "Large-scale pilots for supply end-to-end infrastructures integrating device, network computing and communication capabilities for Telco Edge Cloud deployments, as a basis for Connected Collaborative Computing Networks (3C networks)". The main target of that call is to achieve high TRL results targeting solutions to be adopted by operational networks at a Pan-European Level, enabling the monetisation of new services. The Cluster 4 project will work for and research solutions starting from TRL 3 and ending up to TRL 7, investigating, testing, validating, and demonstrating solutions and prototypes for the simultaneous use of integrated devices, edge and cloud computing, and communication resources in operational environments. Both the IPCEI-CIS and the Cluster 4 activities are targeting existing communication systems (e.g., Beyond 5G systems).

In the context of the SNS-JU, both the public and private sides have identified the need to rapidly develop solutions that are closely related to the 6G networks. More specifically, in the SNS R&I Work Programme of 2025, and taking into consideration the afore initiatives and the results of previous and/or ongoing SNS projects, SNS targets a coherent long-term HEU plan for the telco cloud continuum. Its target is to develop the necessary 6G telco cloud experimental infrastructure, mainly focusing on mid-TRL to provide the means for further integrating SNS-JU solutions (e.g., from past and/or ongoing SNS projects) and testing them in future SNS Stream D trials. The role of this infrastructure is to be used for quick testing and validation of 6G solutions to eventually increase their TRL level and provide the results and solutions to future EU initiatives that will adopt and integrate them into operational networks.

2.2 Global & EU use cases and Trials & Pilots analysis

The goal of this section is two-fold: investigate the main use cases for 6G being discussed at the global scale, on one hand; and, on the other, delve into the initial trials of B5G and 6G experimental systems conducted worldwide. While the results of the comprehensive survey that SNS ICE has conducted regarding global trends have been presented in Section 2.1, including the global prioritization of 6G Use Cases (see Table 2), this section presents the Use Case and T&P trends from European stakeholders, before examining the Trials and Pilots taking place on the international stage.

2.2.1 Use cases and vertical sectors addressed in SNS Call 1 and Call 2 R&D projects

SNS-JU R&I projects have developed a significant amount of use cases targeting different vertical sectors. Crossing inputs between the inputs gathered in the SNS-JU Vertical Engagement Tracker, developed as part of WP3 and the SNS OPS yearly questionnaire it is possible to outline an cross-analysis of the actual reality of use cases currently under development and the expected impact of different vertical sector by each projects.

2.2.1.1 Phase 1 and 2 SNS projects

So far, the input gathered for Phase 1 projects showcases a total of 123 use cases from 36 projects. These have been spread across several vertical sectors with a significant peak (highest tier) for Industry 4.0/Manufacturing (33), followed by Media/xR (20) and Automotive (15). The medium tier sees Security/PPDR (10), Smart city (9) and Smart Health (7). The Lowest tier sees Tourism & Culture (3), Smart Agriculture (2), Non-terrestrial Networks (2), Education (1) and Smart Energy (1). The 20 remaining use cases classified as "Other" mainly refer to cross-

sectoral application across more than one vertical. These include secure data sharing, confidential computing, and cyber threat detection, essential for evolving 6G networks and IoT infrastructures.

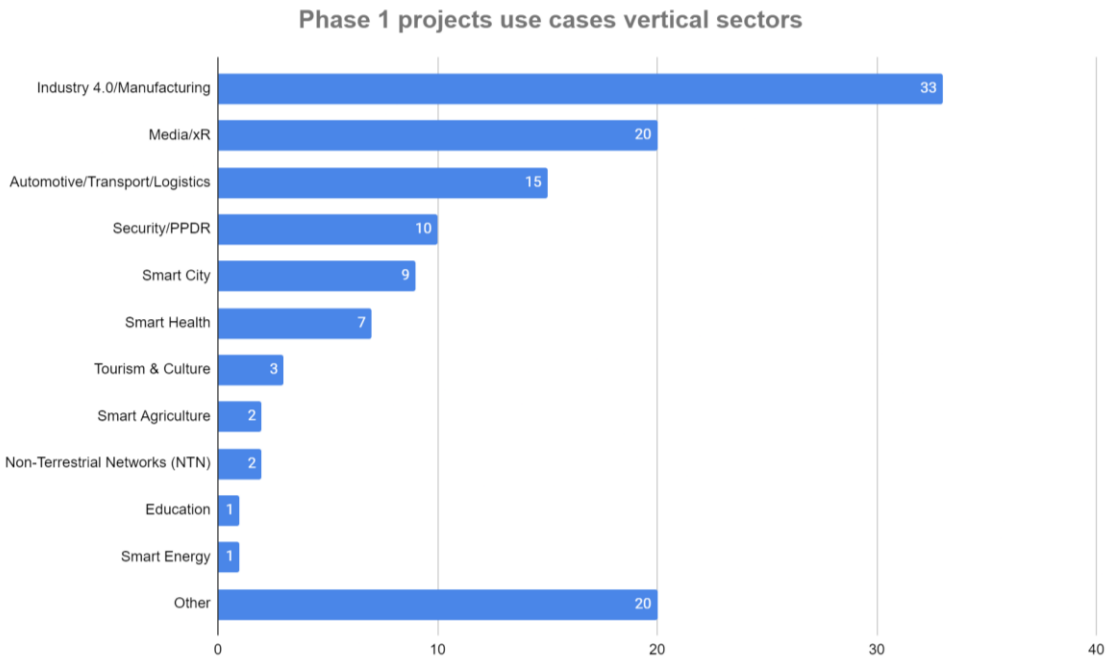

Figure 8: Vertical trends in Phase 1 projects.

Data collection for SNS-JU Phase 2 projects as of November 2024, presents a total of 58 use cases divided across 11 vertical sectors, with rather homogeneous trends. Unlike Phase 1 projects, the "Automotive/Transport/Logistics" sector dominates with 12 total use cases, indicating a significant focus on mobility and transportation innovation. However, the other vertical sectors are aligned with Phase 1. For example, just like in Phase 1 projects "Media/XR" is in second place with a total of 7 use cases, showcasing interest in extended reality and digital media advancements. Sectors like "Industry 4.0/Manufacturing," "Security/PPDR," and "Smart City" each account for 6 use cases, reflecting an emphasis on industrial transformation, public safety, and urban development. "Smart Agriculture" has 4 use cases, double compared to Phase 1. Meanwhile, "Smart Health," "Non-Terrestrial Networks (NTN)," and "Education" each contribute 2 uses, with slightly higher or smaller proportional variations compared to Phase 2 projects. Just like in Phase 1 projects, the "Smart Energy" sector has just 1 use cases, indicating limited activity in this domain, while the "Other" category encompasses 10 projects, representing a variety of additional use cases not confined to the listed sectors.

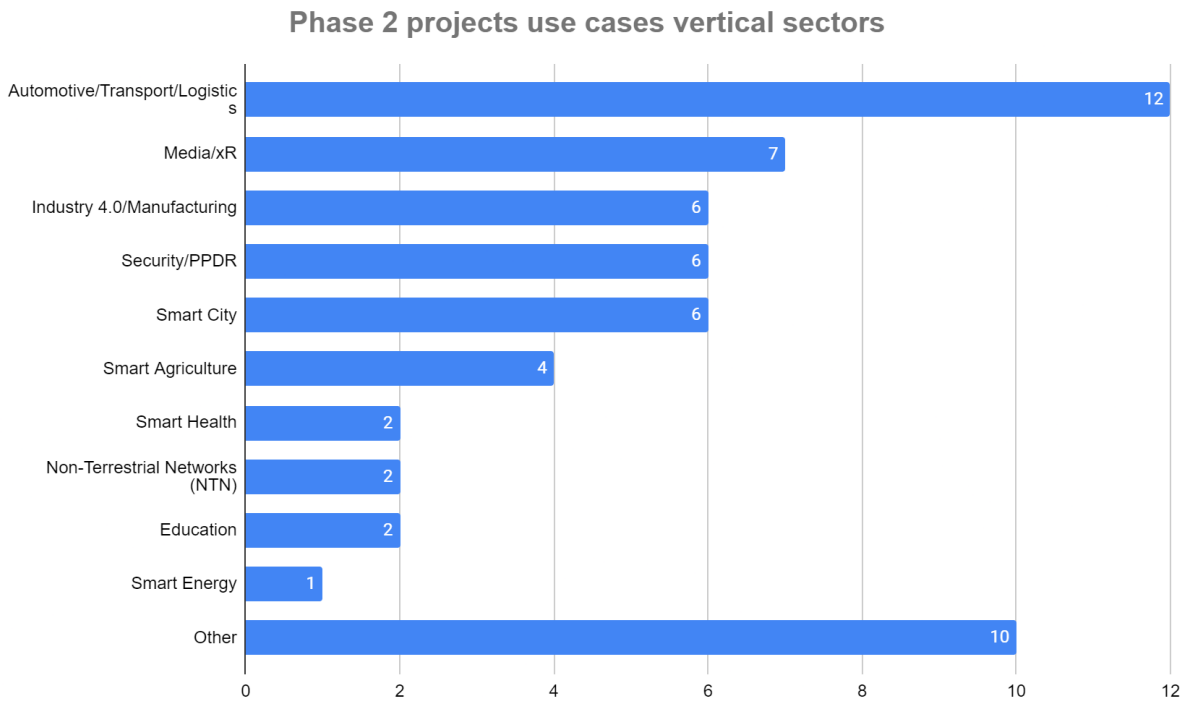

Figure 9: Vertical trends in Phase 2 projects.

Figure 10 summarizes results for SNS Call 1 and Call 2 projects. By taking a look at the addressed vertical sectors and use cases shown, it can be observed that the data are well aligned with the global trends presented in Section 2.1. Industry 4.0, Digital twins, cooperation of robots/cobots, multi-sensory XR-gaming, etc. are on the top of preferences of SNS-JU experimenters as is the case for the rest of the world. An increased interest can be observed within SNS-JU in the Transportation vertical, as the EU has heavily invested in the notion of Connected and Automated Mobility (CAM) and aspires to provide uninterrupted connectivity along all major EU transport paths.

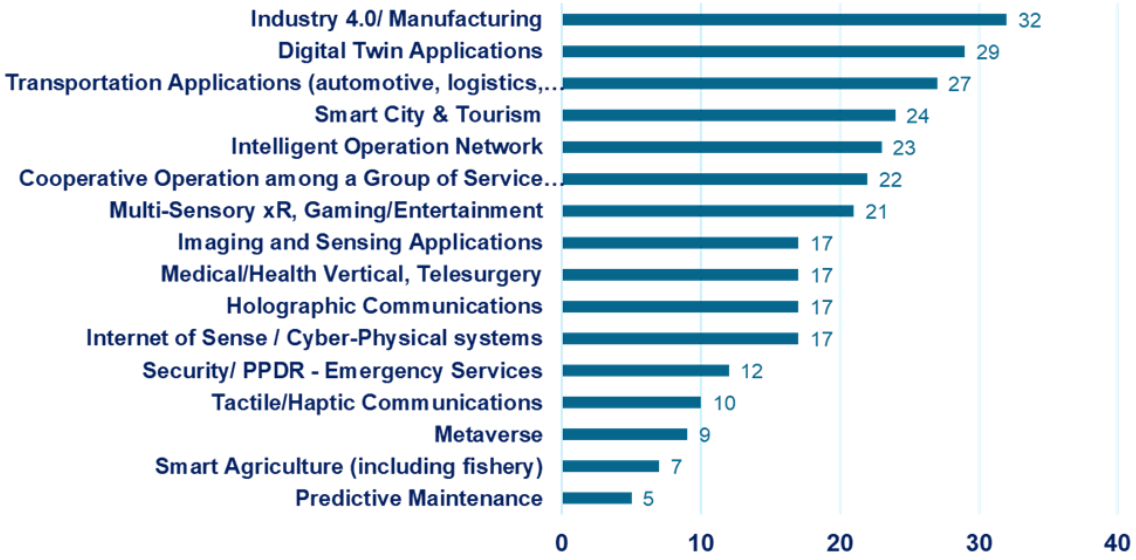

Figure 10: Use Cases / Verticals addressed by SNS Call1 & Call 2 projects[25].

The trends highlighted above find correspondence with the expected impact on vertical sectors as highlighted in the SNS OPS yearly questionnaire as late as 2024, (Figure 11). Performing a cross-check analysis, several

congruences can be observed. In most cases, the same high-tier vertical sectors occupy the first positions in terms of entries, starting from Industry 4.0/Manufacturing (19), to Automotive (13). Media/xR and Healthcare (8), Automotive/Transport/Logistics (7). The only notable delta concerns Smart Citiy, situated in the highest tier (second overall) with 13 entries in contrast to the 9 (fifth overall) of the actual Phase 1 use cases and Security/PPDR with 5 entries (ninth overall) in contrast to the 10 (fourth overall) of the previous graph.

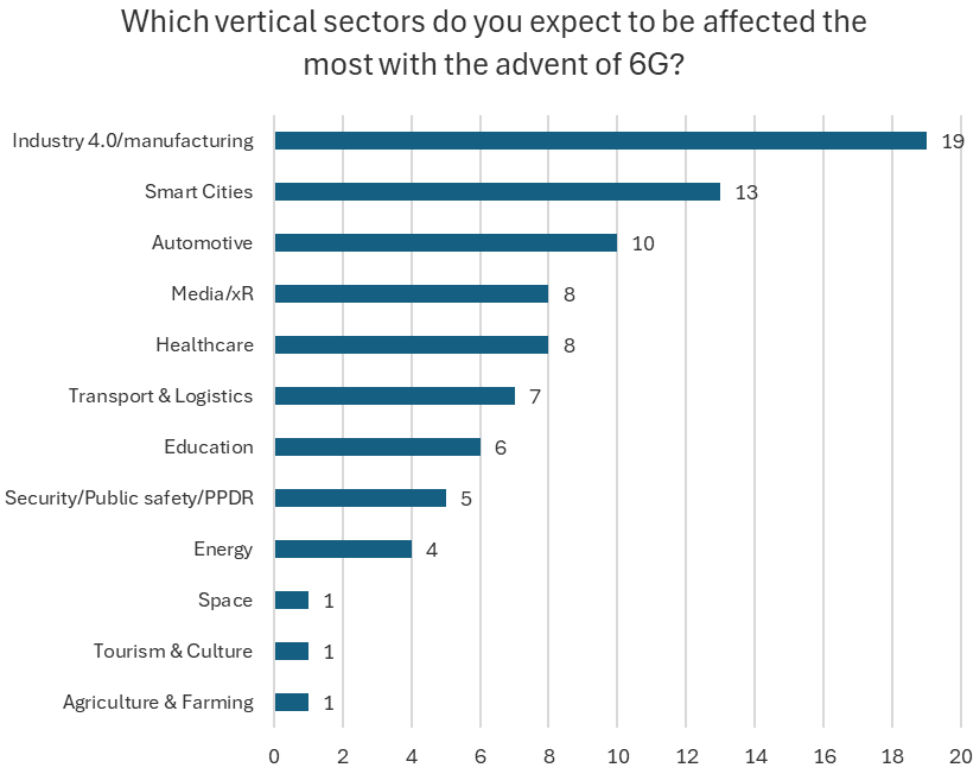

Figure 11: Vertical sectors impact expectation.

A more in-depth analysis of the use cases and corresponding emerging trends in vertical sectors is provided in D3.3 and D3.4.

2.2.2 European use cases and KPIs prioritised at the 3GPP workshop in Rotterdam

At the 3GPP SA1 workshop on 6G use cases (Rotterdam, May 2024)[16], a European R&I view on 6G use cases was presented [15] based on the Hexa-X-II use cases [16] with input from various SNS projects and national 6G initiatives in European member states. The resulting set of use cases is displayed in Figure 12.

[16] https://www.3gpp.org/ftp/workshop/2024-05-08_3GPP_Stage1_IMT2030_UC_WS/Docs/SWS-240018.zip

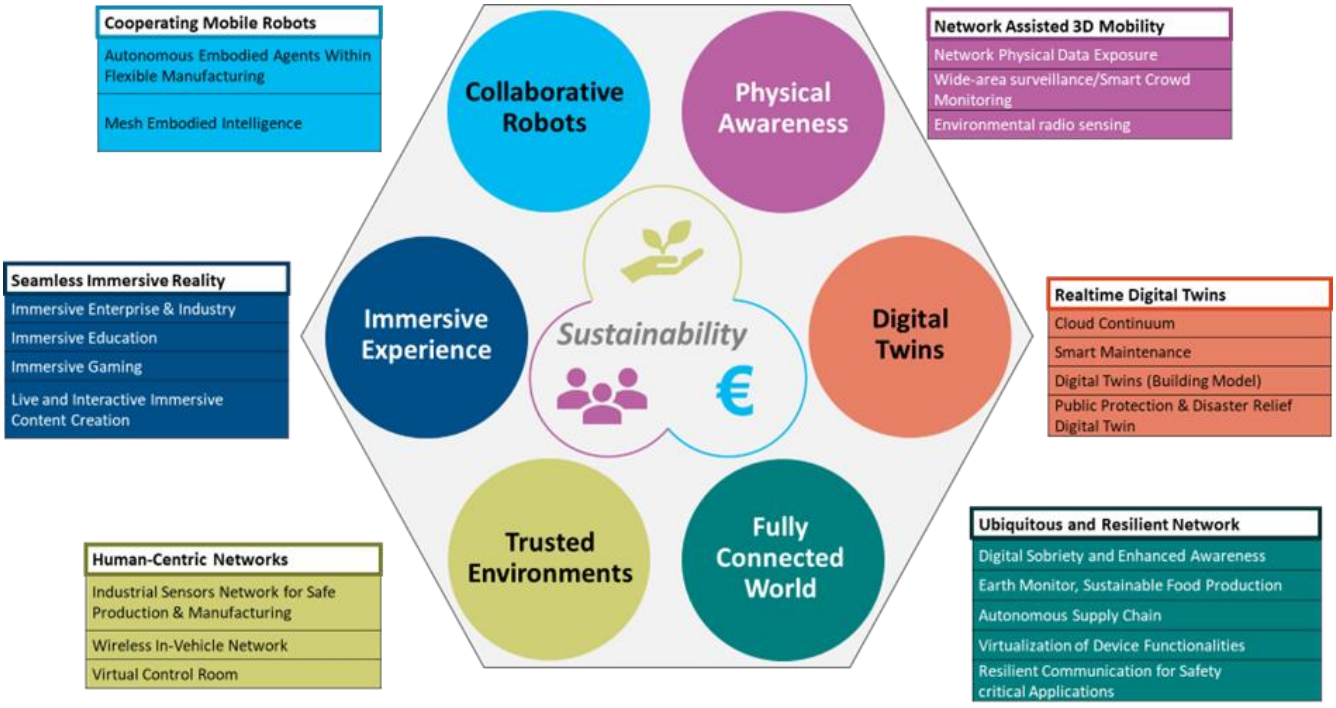

Figure 12: European consolidated R&I view on 6G use cases. Use case families (circles) with the representative use case mentioned first in the list of use cases in the respective family.

The use cases are clustered in 6 use case families. Each use case family includes a number of detailed use cases. The use case best representing the key aspects of each family has been selected as the representative use case and is indicated first in the list of use cases for each family in Figure 12. Use cases' overview descriptions are summarised in Section 2.2.2.1. For each of the representative use cases, use case-specific KPIs are provided. These KPIs emphasize the specific needs that enable E2E featured performance to make the use case possible. The KPIs are summarised in Section 2.2.2.2.

2.2.2.1 Use case families

Immersive experience

This use case family is based on XR technologies. The immersion is built through the combination of immersive and sensorial technologies (e.g., 3D visual perception, spatial audio, haptics) and the synchronisation of data streams so that multiple participants have simultaneous, consistent, and collaborative experiences.

The representative use case for this family is *Seamless Immersive Reality* (*SIR*). Two example scenarios are (*i*) **Immersive collaboration meeting/classroom/event**, describing the possibility of displaying a particular content in an AR/VR/MR environment while interacting with remote and co-located participants; and (*ii*) **Immersive Experiences "on the go"**, where information from the real world is incorporated and used to provide a better user experience (e.g., sight-seeing landmarks) but also can be shared with others (e.g., joint virtual city tour).

To achieve this superior Quality of Experience (QoE) and seamless service continuity, data rates are required beyond what 5G typically delivers, plus strict E2E latency and reliability guarantees. Additionally, new 6G capabilities such as sensing, positioning, and AI/ML are key technology enablers for *SIR*.

Finally, privacy and security requirements are important for the proper functioning of these immersive experience use cases, as vast amounts of data will be transported. Technical, administrative and legislative means are required to protect privacy in a hierarchical and heterogeneous 6G system, i.e. across wide area networks, public and private local networks, as well as subnetworks.

Collaborative robots

This family includes several use cases for intelligent, collaborative, and mobile robots with the ability to move, sense their environment, perform a task, and cooperate with humans or with other robots to achieve a set goal. Application domains include home robots, robots for facility management, robots in daycare or hospitals, as well as robots in flexible manufacturing.

The representative use case for this family is *Cooperating Mobile Robots*. As the name suggests, it revolves around robots being able to move and cooperate safely, enabling them to perform tasks beyond their individual capabilities, and perceive their environment beyond their local sensing capabilities. Furthermore, it focuses primarily on local *ad hoc* connectivity embedded in private networks, and the challenges imposed by the mobility aspects. A few example scenarios are (*i*) **cooperative carrying with robots**, where robots work together to transport an object that exceeds the carrying capacity of a single robot; (*ii*) '**Lot size one' production** where the flexibility and adaptability of cobots enable products to be created individually and uniquely, rather than in batches; and (*iii*) **autonomous farming,** referring to the use of self-driving, smart machines that work collaboratively in agricultural operations.

Related to requirements and KPIs, local *ad hoc* connectivity and extremely reliable and low latency communications are key for this use case. Additionally, Integrated sensing capabilities within the 6G network and devices can enhance the perception of the robots of their environment. The introduction of AI/ML execution in edge nodes can further enhance robot coordination. Finally, a high positioning accuracy is required for tasks such as environment mapping, robot navigation, or localisation.

Physical awareness

This family refers to use cases where sensing and positioning are used together with communication and network intelligence to enable for instance physical scene analysis, tracking, context awareness, trajectory prediction, navigational support, and collision avoidance. Sensing by the radio network can be enhanced by embedded sensors and by information delivered by network nodes and surrounding devices. Example scenarios include cars, automated guided vehicles, and drones as well as pedestrians and bikes.

The representative use case for this family is *Network Assisted 3D Mobility*. Here, networks measure and analyse the physical environment to detect and capture information on objects (e.g., size, speed, trajectories, positioning). From this large data set, information is extracted and relayed to vehicles and/or drones. Thereby, the network can support vehicles with different levels of autonomy and modes of operation, and also enable smart transport in urban areas. Example scenarios comprise: (*i*) **Autonomous drone transport**, whereupon carrying goods in urban areas, drones can be updated in real-time on the fastest and more energy-efficient traffic routes; (*ii*) **Smart intersections**, where vehicles are informed about the conditions at an intersection to advert collisions; and (*iii*) **Assisted vehicles**, which introduces autonomous driving, benefiting from the contextual data resulting from the fusion of wide-area sensor information provided by the network, vehicle on-board sensors and even sensors embedded in the transport infrastructure.

As this use case family aims at preventing undesired outcomes such as collisions, the system is required to be highly reliable, both in communication aspects and data quality/accuracy. Additionally, the availability of reliable compute capabilities offered by the network, and privacy and security are essential to this use case.

Digital twins

This family collects a set of use cases where digital equivalents of the real world are created and displayed for interaction, control, maintenance, as well as process and component management. Digital twins can be part of managing manufacturing plants, construction sites, city infrastructure, or communication networks with or without real-time needs.

The representative use case for this family is *Realtime DTs*. As the name suggests, along with the creation of an accurate digital representation of a given object/process/person, this use case expands the potential offered by

these representations by benefiting from the real-time aspect, which allows extending the digital twin also towards the direct control of ongoing physical processes.

To achieve a *Realtime Digital Twins*, AI/ML, positioning, and sensing capabilities are required to deliver a seamless user interaction. Moreover, network and device interoperability are key to the success of the working ecosystem. This requires using open interfaces and/or relying on strong system integrators. Other specific requirements that the *Realtime Digital Twin* use case brings are 3D coverage, compute capabilities, and privacy/trustworthiness of the network.

Fully connected world

This family unites use cases demonstrating the need for ubiquitous network access and service coverage across the whole population. Ubiquitous access will be enabled both through terrestrial networks (TN) and NTN and amended by infrastructure-less network extensions to wide-area network deployments.

The representative use case for this family is *Ubiquitous and Resilient Networks.* This use case focuses on delivering Mobile Broadband connectivity to every human on Earth, leaving no "white zones". Three main scenarios can be mentioned: (*i*) **Connectivity at remote locations**, providing a user in e.g. a mountainous area with a wide range of services (e.g., remote health consultations, voting, or emergency calls if being lost in the mountains); (*ii*) **Improved connectivity in developing countries**, where also a small-scale farmer can benefit from connectivity for precision farming; and (*iii*) **Connectivity during natural disasters and emergencies**, which builds on the role NTN can play in case of a terrestrial natural disaster (e.g., earthquake, fire, flood) for emergency services and disaster relief.

Ubiquitous and Resilient Networks has a big impact on social (e.g., digital inclusion, education, disaster relief), economic (e.g., deployment cost, new business opportunities), and environmental (e.g., earth monitoring, less invasive deployment) issues, but also increases network resilience significantly. Therefore, the biggest challenge lies in delivering a tight and reliable integration of different networks from the initial phases of 6G.

Coverage is an important KPI for ubiquitous networks. Affordability is important to ensure a widespread adoption.

Trusted environments

This family encompasses use cases with high reliability and privacy requirements as key characteristics. The *Trusted Environments* use cases build primarily on a combination of AI, sensing, and computing capabilities to create spatial and situation awareness to enable context-driven interventions.

The representative use case for this family is *Human-centric services.* This use case describes three scenarios that put humans at the centre of a wide range of 6G services: (*i*) **Precision healthcare**, which delivers personalised diagnosis and treatment; (*ii*) **Safe environments**, based on spatial- and situation awareness to prevent accidents or trigger changes in the environment (e.g., ramps deployment); and (*iii*) **Public safety services during big events**, aimed at predicting disorder and delivering solutions to aid the people in moments of need.

When dealing with health and well-being scenarios, delivering services imposes very high privacy requirements and consequently requires mechanisms to ensure data is held secure and the system is trustworthy (e.g., anonymisation, additive homomorphic encryption). Availability and reliability also play a key role.

Besides, AI/ML and sensing capabilities, being fundamental in delivering these services, reliability and connection density are some of the most pressing KPIs.

2.2.2.2 KPI summary

This section summarises the relevant KPIs that have been identified for the different representative use cases within the use case families (see Table 5 next).

Table 5: KPIs to consider for 6G representative use cases.

	Seamless Immersive Reality	Cooperating Mobile Robots	Network Assisted 3D Mobility	Realtime DTs	Ubiquitous and Resilient Networks	Human-Centric Networks
User experience data rate [Mb/s]	< 250	< 10	< 100	< 100	DL: 0.1 - 25 Mbps | UL: 2 Mbps	-
Mobility [km/h]	Pedestrian, up-to vehicular speeds	<20	<300	<100	<120	Pedestrian, slow vehicular
E2E latency [ms]	< 10 ms for split rendering | < 50 ms for voice | < 150 ms for collaboration	< 0.8	1-20	< 1	10-100	< 250 ms for AGV and care robots | < 1000 ms for initiating an intervention
Reliability [%]	99.9 - 99.999 %	99.999-99.99999 %	99.99 %	99.999 - 99.99999 %	99.9 - 99.999 %	99.99 - 99.999 %
Connection density [devices/m^2]	-	< 0.1-1	0.01 d/m^2 0.01 d/m^3)	1-10 d/m^3	0.1	1-10 indoor | <0.001 outdoor
Area Traffic Capacity [Mb/s/m^2]	< 250 Mbps/m2 for Indoor, per floor | <20 Mbps/m2 for outdoor	-	-	-	-	-
Service Availability	-	-	99.99 %	-	98.5 %	-
Coverage	-	-	99.9 %	99.99 %	Up to 10-15 kms range (cell radius) | 99.9% area coverage with integrated networks	-
Positioning Accuracy [m]	<= 0.1, horizontal & vertical	< 0.1 fine, <1 coarse | 99.9% availability	1 (3D) precision with 99.9% reliability within 99.9% of service space (0.1)	<= 0.1	< 10 | 99% of availability	< 10 location accuracy | <0.3 - <1 positioning accuracy | <0.1 relative positioning accuracy
Sensing-Related Capabilities	YES / Required	YES / Required	YES / Required	YES / Required	NO	YES / Required
AI/ML-Related Capabilities	YES / Required	YES / Required	YES / Required	YES / Required	NO	YES / Required

2.2.3 Replicability of 6G use cases

The replicability initiative has the objective to identify use cases and solutions developed and experimented by SNS projects that could be replicated elsewhere. The idea is to provide to the Digital Innovation Hubs, members of SCoDIHNet, a catalogue of replicable use cases with the respective level of replicability. This will help SNS project technology providers to bring innovative solutions and to promote SNS-JU innovation to end users.

For that purpose, a specific question was introduced in the SNS OPS questionnaire 2024 (**T8: Which methods will your project use to validate the technologies developed?)** in order to identify replicable use cases.

A number of Call 1 and Call 2 projects are developing use cases in order to show and validate the technologies, a few of them from Stream A and Stream B projects and most of them from Stream C and Stream D projects. These use cases are addressing most of the verticals and targeting TRL 3-4 (PoC) for Stream A and B projects and TRL 5-7 (Trials/Pilots) for Stream C and D projects.

A replicable use case could be for instance the development a solution ensuring water saving according to the phenological stages of the crop which has been experimented in Spain. Such solution could be reused by DIHs to replicate it in other location in Europe. It could also be a use case addressing the education sector by introducing an XR-enabled learning platform to support two rural schools in Romania or use cases targeting Industry 4.0 with the development of Digital Twin in Finland that should also be interesting for other manufactures in other locations.

Phase 1 projects were asked to provide the replicability level (using the replicability assessment tool) of each replicable use cases and Phase 2 project were asked to provide a first vision of the number of replicable use cases they are planning to develop.

- 15 Phase 1 projects have declared 74 replicable use cases with a good replicable level
- 9 Phase 2 projects are planning to develop 54 replicable use cases

These 128 replicable use cases are covering all vertical sector with a big emphasis on Industry 4.0

All these uses cases will feed the Replicability catalogue which is available to SCoDIHNet members, they have the possibility to pick one or the other with regards to the end users needs.

2.2.4 Analysis of International Trials and Pilots

This section reports on selected trials and pilots being carried out at the global scale and the corresponding industrial associations and funding programmes underpinning them. Desktop research indicates that, in general, the level of involvement of vertical industries is quite limited. Hence, the substantial and sustained investment in Large Scale Trials and Pilots with Verticals made under the umbrella of the SNS R&I Work Programme (Stream D) is likely to provide Europe with a competitive advantage in this area.

Japan

In Japan, the XG Mobile Promotion Forum[17] (XGMF, formerly, 5GMF) is the industrial association in charge of fostering the adoption of 6G technology and beyond. In what concerns international aspects, it is aimed to promote industry-academia collaboration, sharing 5G/6G global information, and strengthening international coordination. XGMF acknowledges that cooperation between the ICT field and vertical sectors is vital to develop technologies and examine solutions for practical use. This vision is embedded into the 3-phase programme structure it envisages. The current phase, Phase 1, focuses on the examination of solution value and it already includes collaboration with selected verticals. It comprises 24 projects on promising technologies for 6G. Phase

[17] https://xgmf.jp/en/

2, which is set to start in 2025, will deal with system development aspects and development of interfaces (APIs) to the ICT infrastructure, as per the requirements based on the solution values identified in Phase 1. From 2027 onwards, Phase 3 will tackle practical network developments.

As part of the solution examination phase, in early 2024 NTT DOCOMO partnered with several companies to conduct 6G technology trials, with a particular emphasis on (sub)THz communications. The consortium, led by DOCOMO, included Nokia, Fujitsu, Keysight, Ericsson, and NEC.

Nokia conducted trials of wireless access technology at 140 GHz, while Fujitsu focused on distributed MIMO trials at 100 GHz and 300 GHz. Keysight Technologies developed an architecture for sub-THz propagation measurement, along with channel modelling and propagation analysis. NEC contributed a multi-element active phased array antenna with over 100 elements, supporting 100 GHz equipment, complemented by Fujitsu's high-output amplifier designed for both frequency bands. These efforts enabled data transmission at 100 Gb/s over distances of up to 100 meters.

Ericsson, meanwhile, explored wireless transmission in the 6.5 GHz band, broadening the scope of the experimental activities. More recently, Nokia and SK Telecom collaborated on integrating AI into the radio air interface, reducing signalling overhead and achieving a 30% improvement in signal throughput. Rhode & Schwarz contributed by evaluating propagation aspects and the performance of wireless sensing technologies.

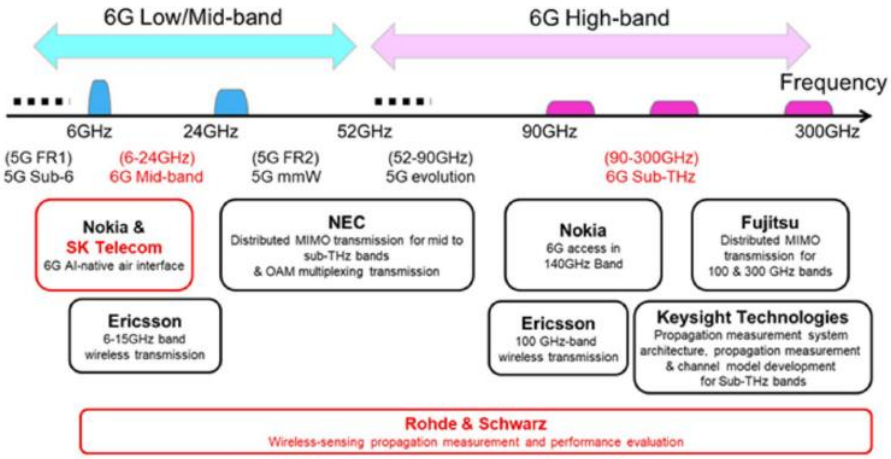

Figure 13: Roles of the various companies involved in the NTT DoCoMo-led trials conducted in 2024.

China

Shanghai Nokia Bell, Ericsson, China Mobile, China Telecom, China Unicom, Huawei, ZTE, Vivo and Inspur have been reported to participate in China's 6G technical trials and tests in 2023 [31]. In the area of Non-Terrestrial Networks, [32] indicates that one of the recently launched LEO satellites is the world's first to implement 6G design architecture, developed collaboratively by China Mobile and the Innovation Academy for Microsatellites under the Chinese Academy of Sciences. The 6G test satellite incorporates a distributed autonomous architecture, built using domestically developed software and hardware. It supports in-orbit software reconfiguration, flexible deployment of core network functions, and automated management. These capabilities are said to enhance the efficiency and reliability of the satellite's core network during its operation in orbit.

US

6G research in the US is tackled from three complementary angles. On the one hand, the US government plans to invest $52 Bn for the Chips & Science Act. Out of them $2Bn are allocated to the Microelectronic Commons (MEC), which is run by the DoD. Research in 5G/6G included is part of the MEC, with a clear focus on Open Radio Unit innovation and commercialisation. In addition, two main programmes run by the NSF are in place for academic research: the NSF SpectrumX programme which includes the establishment of a Spectrum Innovation

Center; and NSF RINGS (Resilient and Intelligent NextG Systems) that has funded 41 projects in total, with its follow up RINGS 2.0 programme set to start in 2025. RINGS and RINGS 2.0 are structured in five distinctive areas (groups), namely,

- Group A: Physical and link layer (circuits, hardware, antennas w/ physical layer, coding, signal processing, etc.)
- Group B: Network and cloud (edge computing, cloud with networking, machine learning with optimisation)
- Group C: Security and trust (security, privacy, blockchain)
- Group D: Network research infrastructure
- Group E: Emerging verticals and use-based driven research

this has allowed to fund a number of large B5G/6G testbeds and platforms (e.g., PAWR) for advanced wireless experimentation, spectrum innovation, 6G fundamentals, etc.

Finally, ATIS and the NextG Alliance (NGA) have a leading role in what concerns industrial research and the development roadmap for 6G introduction, adoption and commercialization in the US. In line with this, T-Mobile in partnership with Nokia and NVIDIA, announced in September 2024, the launch of new cutting-edge AI-RAN innovation centre aimed to revolutionize customer experience in xG communication networks.

2.3 Key insights based on SNS-ICE analysis

The global 6G landscape is evolving rapidly, with a **significant alignment in priorities among key international stakeholders**. The information and analysis presented in this section highlights that European 6G research and innovation closely aligns with global priorities, as outlined in the ITU's IMT-2030 Recommendations published the same year. These recommendations established foundational high-level scenarios and key performance indicators (KPIs) that are driving 6G development worldwide.

Among the **most critical technologies for 6G**, several have emerged as universally accepted priorities:

- **Sustainability and energy efficiency**, essential for addressing environmental challenges.
- **Trustworthiness** (security, reliability and privacy), reflecting a growing emphasis on robust, trustworthy networks.
- **AI-native intelligence**, which transforms AI from an added feature to a fundamental building block of network design.
- **Integrated sensing and communication** (ISAC), enabling seamless integration of communication and environmental sensing.
- **Cloud-native and distributed edge computing**, which promise scalability and efficiency.
- Ubiquitous **connectivity via non-terrestrial networks** (NTN), ensuring coverage in remote and underserved areas.
- Spectrum efficiency and **innovative spectrum sharing methods**, which are vital for managing increasing data traffic demands.

In terms of **use case focus** for 6G the following priorities have been identified**: autonomous mobility** applications, **immersive and holographic communications** (spanning AR, VR, and XR technologies), **digital twin applications** for real-time process management, and robotics involving cooperative capabilities. Other prominent use cases focus on ubiquitous and resilient networks for connectivity in remote areas and human-centric services like precision healthcare and public safety.

Europe is playing a leading role in this landscape by shaping 6G standards and technologies. It is actively collaborating with bodies like ITU, ETSI, and 3GPP to define critical benchmarks and ensure interoperability. European research and development (R&D) projects focus heavily on transformative verticals such as Industry 4.0, automotive advancements, media, and smart cities. These projects emphasize KPIs like energy efficiency, reduced latency, and enhanced reliability, with AI and edge computing serving as central enablers.

Efforts to standardize 6G are advancing, particularly within 3GPP and ETSI. The 3GPP roadmap includes milestones like Release 20 in 2025 and Release 21 in 2030, which will deliver the first full technical specifications for 6G. ETSI is contributing with initiatives like Terahertz communications and zero-touch network management. Additionally, international trials in Japan, China, and the US are driving technological innovation through significant investments in AI, spectrum optimization, and infrastructure development.

Main conclusions

The transition to 6G is marked by a **global convergence on key technological priorities and use cases**. Across regions, there is universal recognition of sustainability, privacy, and AI integration as central pillars for the next generation of networks. Notably, AI is evolving from a supplementary technology to a core component of 6G architecture, signalling a fundamental shift in network design philosophy. Integrated sensing and communication (ISAC) and ubiquitous connectivity through NTN further underline the transformative potential of 6G.

Europe stands out as a leader in the 6G ecosystem, leveraging its well-aligned research priorities and active contributions to global standardization. European initiatives not only influence critical benchmarks but also focus on addressing societal and economic challenges, such as ensuring digital inclusion and advancing connected mobility solutions. However, **Europe's reliance on non-European cloud providers poses a significant challenge**, highlighting the urgency for achieving technological sovereignty.

Technical challenges remain significant, especially in improving energy efficiency and reliability. Addressing these will require sustained research and cross-sector collaboration. Furthermore, **standardization efforts are critical** for ensuring interoperability and maintaining competitiveness in the global market. Europe's proactive role in shaping standards demonstrates its commitment to maintaining a leadership position.

The 6G ecosystem will also benefit from a broader focus on under-represented sectors like agriculture and education. **Open-source and interoperable solutions will play a vital role** in expanding 6G adoption and ensuring equitable access to its transformative potential. In sum, the transition from 5G to 6G offers an unprecedented opportunity to address technological, economic, and societal priorities on a global scale.

3 Global Dialogues and Roadmap

In the process of building a global 6G ecosystem, it is of utmost importance to establish alliances with selected worldwide organizations. This can be achieved by signing dedicated Memorandums of Understanding with them. Section 3.1 reports on the massive work carried out by the 6G-IA, SNS ICE and other organizations in this respect. Details on the scope and main activities envisaged in those MoUs are provided. To have a clearer view of related achievements, the section also includes information on selected and recent activities undertaken by SNS ICE/6G-IA towards the implementation of those MoUs. Next, in Section 3.2, we turn our attention to describe SNS ICE/6G-IA's approach to consensus building, which leverages on the communication of its key strategies for 6G in the context of position papers, fostering the collaboration with other regions in the context of the SNS R&I Work Programme, identifying synergies with IPCEI-CIS and Cluster 4 activities on telco-cloud, as well as liaison activities with other EU programmes such as Digital Europe (DEP) and Connected European Facility (CEF) .

3.1 Building a global 6G ecosystem: MoUs with worldwide organizations and selected verticals

The elaboration and implementation of bi- and multi-lateral MoUs with international organizations lays the grounds for the creation of a global R&I ecosystem towards the collaboration in 6G. The growing trend of 6G-related MoUs highlighted in D1.1 has been advancing throughout 2024, with notable alliances forming among key players within the telco R&D community and industrial sectors worldwide. To capture the full scope of this movement, a comprehensive overview from January 2022 to October 2024 is provided in this section, illustrating the accelerating momentum in 6G-related collaboration.

SNS ICE and the 6G-IA are very active in establishing MoU and signing Letters of Intent with worldwide organizations[18]. Table 6 below provides detailed information for the MoUs signed since 2022, this including the main objective(s) along with the key collaboration areas. This, clearly, goes one step beyond the information contained in deliverable D1.1, mainly consisting in a statistical analysis of the existing MoUs plus information on the missions of such worldwide organizations. This will allow a more detailed analysis of the strategy behind and the degree of alignment among such organisations, that will be presented in Section 3.4 ahead.

Table 6: MoUs between the 6G-IA and worldwide organisations.

Signatory, region/country, date	Main objective(s)	Key collaboration areas
Next G Alliance/ATIS USA - August 2022	Fostering cooperation on 6G communication systems.	Exchanging information and organizing workshops, seminars, webinars, and trials on 6G-related topics, aligning North American and European efforts in 6G advancement.
Beyond 5G Promotion Consortium (B5GPC) Japan - May 2022	Building a robust framework for international collaboration, aiming to drive forward next-generation networks through mutual expertise and joint initiatives.	Exchange of insights on 6G vision, technology dissemination, and establishing global standards Defining fundamental system concepts, architecture, and use cases for 6G, along with supporting the global regulatory process for spectrum allocation. Promoting cooperation among European and Japanese R&D organisations, fostering a globally harmonised 6G landscape.

[18] https://6g-ia.eu/our-mou-loi-with-associations-and-partnerships/

Taiwan Association of Information and Communication Standards (TAICS) Taiwan – May 2023	Fostering international cooperation towards a single global 6G standard.	Collaboration between European and Taiwanese stakeholders, supporting the development of a unified approach to future 6G communication systems and networks.
Bharat 6G Alliance India – March 2024	Aligning efforts on 6G vision, requirements, architecture, and use cases while promoting globally harmonised standards for Beyond 5G and 6G.	Strengthening cooperation between European and Indian R&D organisations and industries focusing on secure telecommunications and resilient supply chains.
IMT-2030 (6G) Promotion Group China - Jun 2022	Uniting European and Chinese research efforts to support global 6G advancements.	Exchanging information, aligning 6G vision and requirements, coordinating on spectrum policy, and developing a unified global 6G standard. Hosting joint activities—such as workshops, webinars, and trials—to reinforce collaboration and facilitate shared progress in 6G research and deployment.
6G-Platform Germany Germany, June 2023	Promoting and supporting R&D in the areas of beyond 5G and 6G mobile communications and applications.	Exchanging information regarding areas of mutual interest in the field of 6G. Exploring collaboration opportunities on 6G Vision and requirements, technology exploitation, development of global standards, engaging vertical industries, definition of use cases.

Before 2022, 5G-IA was also very active building up international cooperation for 5G networks in the context of 5G PPP. More specifically, it signed MoUs with ENCQOR (Canada), 5G Americas (USA), TeleBrasil 5G (Brasil), TSDSI India, IMT2020 (China), 5G Forum (Korea), and 5GMF (Japan). In the scope of the SNS-JU, the existing MoUs were renewed. Where needed, new ones were signed with the corresponding follow-up peer organisations (e.g. IMT 20230 PG for IMT2020, Bharat 6G Alliance for TSDSI, or Next G Alliance for 5G Americas) in order to keep these global links active.

SNS ICE is also very active in increasing the active engagement of stakeholders from vertical sectors, associations, standardisation and regulatory bodies. The goal is to create a wide ecosystem with vertical industries to promote 5G evolution to 6G while gathering trends and needs from those industries to feed 6G research. SNS ICE has reinforced the role and activities carried out under the Vertical Engagement Task Force, a special team created within 5GIA Board and now reiterated under 6GIA Board. Several consortium members (e.g., TIM, NOKIA, TNO, EURESCOM, 6G-IA, CTTC) are strongly committed to this activity. Table 7 below provides details about all the bilateral agreements that the 6G-IA has established with such organisations.

Table 7: MoUs between the 6G-IA and vertical associations, standardisation and regulatory bodies.

Organisation and date	Main objective(s)	Key collaboration areas
European Rail Infrastructure Managers Association[19] (EIM) December 2024	Enhancing digital integration and drive further innovation in rail systems.	Exchange of information and ensuring that the needs of railway infrastructure managers are effectively integrated into the development of 6G technologies.
5G Media Action Group[20] (5G-MAG) September 2023	Forming a strategic alliance to advance next-generation communication networks, systems, and applications.	Sharing insights, participating in workshops, meetings, and webinars, and exploring joint research projects and trials.
European Telecommunications Standards Institute[21] (ETSI) January 2023	Enhancing the alignment between European research, standards, and industry.	6G-IA's participation in ETSI's Research, Innovation, and Standards Ecosystem (RISE) and the Technology Radar activities. Strengthening European standards for the global market by aligning strategic visions and addressing societal challenges
CELTIC-NEXT[22] April 2022	Promotion of cross-program discussions	Reciprocally contribute to each other's Strategic Research and Innovation Agendas, paving the way for impactful, sustainable ICT advancements in Europe and allied regions. Workshops, and strategic activities that address 5G and 6G technologies from an end-to-end perspective, emphasizing their economic, environmental, and societal benefits.
Association for European nano-electronics activities[23] (AENEAS) June 2022	Enhancing collaboration with a focus on supporting Europe's leadership and technological sovereignty in beyond 5G and 6G networks	Sharing non-confidential insights through webinars, conferences, and information-sharing events, with a particular emphasis on engaging SMEs and fostering cross-domain innovation. Collaborative strategic research, increased coordination in funding, and the cross-fertilisation of the ECS and SNS ecosystems to support impactful innovation.
5G Automotive Association[24] (5G AA) August 2022	Fostering collaboration on Vehicle-to-Everything (V2X) and Connected and Automated Driving (CAD) technologies.	Supporting the development of connected and automated mobility solutions that address pressing societal needs, such as road safety and sustainable urban transportation. Creating a globally integrated approach for next-generation standards, benefiting the mobility sector and society as a whole.

[19] https://6g-ia.eu/single_post/?slug=eim-and-6g-ia-sign-a-memorandum-of-understanding
[20] https://idw-online.de/en/news821855,
[21] https://5g-ppp.eu/6g-ia-and-etsi-sign-mou-bridging-the-gap-between-european-research-standards-and-industry/
[22] https://www.eurescom.eu/eurescom-messages/summer-2022/memorandum-of-understanding-with-6g-ia-signed/
[23] https://aeneas-office.org/2022/06/07/aeneas-and-6g-ia-join-forces-to-build-synergies-for-european-leadership-in-next-generation-telecommunications/.
[24] https://6g-ia.eu/single_post/?slug=5gaa-and-6g-ia-sign-a-memorandum-of-understanding.

European Space Agency[25] (ESA) October 2018	Enabling new and innovative solutions and services in support of European industry and further strengthening the ties with the space sector	Supporting innovation by leveraging existing resources and facilities. Planning joint activities including promotional events as well as additional trials and pilot or demonstration projects in specific markets.
European Cyber Security Organisation[26] (ECSO) December 2018	Establishing a common and coordinated strategy for a secure and trustworthy 5G communication network with an impact on e.g., e-health, industry 4.0, intelligent transport, entertainment & media sectors.	Exchanging information and experience in the field of cyber security and 5G, to identify and address the needs of vertical sectors and research priorities for the development of secure technologies and reliable 5G platforms, as well as to prevent fragmentation in terms of technology deployment across borders and sector.
ERTICO[27] November 2019	Facilitating the roll out of Intelligent Transport Systems and Services (ITS) supported by a secure and trustworthy 5G communication network in Europe.	Contributing insights, engaging in workshops, meetings, and webinars, and exploring collaborative research projects and trials.
Public Safety Communication Europe[28] (PSCE) May 2018	Ensuring that 5G will bring the necessary developments to the security and safety communications for improving the activities of the PPDR community.	Exchanging information on 5G developments Participating in industry events, congresses and joint promotional activities Contributing expertise to enhance the inputs of PPDR stakeholders and Verticals on the development and deployment of 5G
New European Media Initiative[29] (NEM) May 2020	Strengthen the liaison between EU funded projects working on research, testing and deployment on media & content topics with the relevant industry players	Consulting NEM members to contribute to 5G IA working items (projects, trials, initiatives, actions and other activities) Sharing documents between the Parties Invitations to participate in meetings organised by the other signatory (e.g., of 5G IA Media WG, Trials WG, NEM meetings). Work towards supporting each other in promoting international cooperation and marketing support

[25] https://5g-ppp.eu/european-space-agency-and-5g-infrastructure-association-cooperate-to-support-europes-5g-vertical-markets/

[26] https://6g-ia.eu/ecso-and-5g-ia-sign-memorandum-of-understanding/

[27] https://6g-ia.eu/ertico-its-europe-and-5g-ia-sign-memorandum-of-understanding/

[28] https://5g-ppp.eu/cooperation-agreement-to-foster-developments-on-5g-for-public-safety-stakeholders-between-5g-ia-and-psc-europe/

[29] https://nem-initiative.org/nem-and-5g-infrastructure-association/

5G Alliance for Connected Industries and Automation[30] (5G-ACIA) October 2020	Facilitating the roll-out of future plants and factories supported by a secure and trustworthy 5G communication network in Europe and across the globe.	Strengthening the cooperative relationship and fostering a closer channel for exchanging views, joint marketing and promotion activities Identification of research needs, for example, supporting the framing of suitable public funding programs and initiatives.
Alliance for Internet of Things Innovation[31] (AIOTI) June 2018	Exploring opportunities for new combinations of IoT applications built on world-class digital infrastructures.	Exploring topics of common interest relating to technologies and solutions that will shape the way we live and work. Including the aforementioned topics in a Joint Strategic Research and Innovation Agenda (SRIA).
Trans-Continuum Initiative[32] (TCI) December 2020	Developing a vision of the infrastructure required for the convergence of data and compute capabilities in many leading edge industrial and scientific use scenarios.	Elaboration of joint recommendations for R&D to be carried out in EU- or JU-funded Work Programmes addressing challenges in the digital continuum. Engaging with EU Research & Innovation funding entities to promote those recommendations. Fostering an interdisciplinary network of experts in science and industry. Contributing to Strategic Research and Innovation Agendas Contributing to the 5 Horizon Europe missions
Networld Europe[33] July 2021	Fostering cooperation and synergies on European Research Activities on the ICT sector for Smart Networks and Services.	Capturing the mutual understanding of the challenges and opportunities in the European Research and Innovation ecosystem in the context of Horizon Europe for the next decade.
Next Generation Mobile Networks (NGMN) February 2022	Supporting the development of a non-fragmented, global, innovative, and affordable telecommunication services.	Exchange of information in areas of mutual interest Jointly organise meetings conferences and workshops promoting issues of mutual interest and their partnership.
SCODIHNET[34] March 2022	Supporting the creation and the operations of Smart Connectivity Digital Innovation Hubs nodes at European level and worldwide.	Supporting Digital Innovation Hubs that are providing services on 5G/6G, IoT/Edge Computing, Cybersecurity and artificial intelligence (AI).

[30] https://6g-ia.eu/5g-acia-and-5g-ia-sign-mou-to-foster-cooperation-and-synergies-on-mobile-radio-communication-enabled-industrial-iot/

[31] https://aioti.eu/wp-content/uploads/2018/12/5G-IA-and-AIOTI-MoU-Announcement-Final.pdf

[32] https://ecs-org.eu/8-european-associations-and-projects-commit-to-the-trans-continuum-initiative/

[33] https://www.networldeurope.eu/wp-content/uploads/2021/07/joint-press-release-networldeurope-5g-ia_final.pdf?x43385

[34] https://aioti.eu/wp-content/uploads/2024/02/SCoDIHNet-Flyer-22012024.pdf

ECC April 2017	Ensuring the most efficient use and management of the radio spectrum for global harmonisation of mobile broadband systems.	Exchange information and seek a common approach concerning mobile broadband systems and related use of the radio frequency spectrum.

As in the case of worldwide organisations, some of those links between the 6G-IA, peer organisations and vertical associations were already established under the umbrella of the 5G PPP. Similarly, those MoUs have been kept alive and further strengthened on the road to 6G networks and potentially add any missing links with further key stakeholders. Specifically, in 2024 new MoUs has been established. This includes the Bharat 6G Alliance, an initiative led by Indian industry, academia, and national research institutions, aligned with the Government's Bharat 6G Mission. Its mission is to design and deploy intelligent, secure solutions to enhance the quality of life in India and globally. The alliance supports research, IPR creation, testing, and certification in telecom product innovation to position India as a leader in affordable and purpose-driven telecom technologies. Its main objective and key collaboration areas are listed in Table 7 above. Besides, the SNS ICE project has also supported in 2024 the preparation of a new MoU to be signed by 6GIA and the **European Rail Infrastructure Managers (EIM)**. The MoU will be finalised before end of year and it is very relevant, considering that a call for projects for the Railway sector is part of the SNS-JU Work Programme and a Strategic Development Agenda (SDA) for the railway sector is being lunched under the CEF program.

3.1.1 Other MoUs without the participation of SNS ICE/6G-IA as a signatory

This section reports on a number of MoUs and LoI where SNS ICE or the 6G-IA has not been directly involved. The goals is two-fold: (i) to stress the fact that the intention to build consensus and harmonise technology push with market pull is of a truly global nature; and (ii) to provide the right context for some activities conducted by SNS ICE in the context of those MoUs, as it will be discussed in Section 3.1.2 ahead. A non-exhaustive list of such MoUs and their respective goals includes the following:

- **EU – Japan,** April 2024: Simplifying e-commerce and cross-border business by harmonizing digital identity initiatives, advancing semiconductor research, cooperation in cybersecurity, AI, and high-performance/quantum computing; exploring robust submarine cable infrastructure.[35]
- **Next G Alliance (US) – Beyond 5G Promotion Consortium (Japan),** May 2022: Fostering collaboration on the development of future 6G wireless networks to align North American and Japanese efforts to shape a robust 6G ecosystem globally.
- **Next G Alliance (US) - Bharat 6G Alliance (India)**, September 2023: Aligning research and development priorities to create secure telecommunications networks and resilient supply chains, supporting a shared vision for 6G innovation.
- **6G Flagship (Finland) - Bharat 6G Alliance (India)**, September 2023: Aligning research and development priorities, creating secure telecommunications standards, and reinforcing supply chains for 6G components[36].
- **6G-SANDBOX (SNS Project) – European Space Agency (ESA),** June 2023: Establishing an open innovation laboratory focused on integrating non-terrestrial network (NTN) capabilities by enhancing the 6G-SANDBOX testbed with incorporating satellite connectivity in various orbits.
- **6G-SANDBOX (SNS Project) - Industrial Technology Research Institute (Taiwan)**, November 2023: Strengthening cooperation between European and Taiwanese enterprises in 6G research and connecting 6G-SANDBOX's testbeds with Taiwan's telecommunications ecosystem[37].

[35] https://ec.europa.eu/commission/presscorner/detail/en/ip_24_237
[36] https://www.6gflagship.com/news/6g-flagship-and-bharat-6g-alliance-sign-a-memorandum/.
[37] https://itritoday.itri.org/115/content/en/unit_03-1.html.

- **Industrial Technology Research Institute (Taiwan) - EURECOM (France)**, June 2023: Advancing 6G technologies through a strategic collaboration in joint communication and sensing (JCAS), reconfigurable intelligent surfaces (RIS), AI-native networks, and Open RAN Network architecture.
- **Northeastern University (US) - Singapore University of Technology and Design (Singapore)**, February 2024: Collaborating in research and development for next-generation wireless networks, focusing on Open Radio Access Network (RAN) and 6G technologies[38].
- **Ericsson (Sweden) – Turkcell (Turkey)**, February 2024: Advancing technological innovation in Türkiye, leveraging the expertise of Turkcell's 6GEN Lab and Ericsson's research site in Istanbul[39].
- **MediaTek (Taiwan) - Singapore University of Technology and Design (Singapore)**, June 2024: Strengthening Singapore's role in the global 6G ecosystem and aligning with MediaTek's efforts in global 6G research and standardisation at 3GPP.[40]
- **SK Telecom (South Korea) – Singtel (Singapore)**, July 2024: Collaborating on advancing next-generation communication networks, artificial intelligence (AI), and 6G technology.

3.1.2 Selected activities undertaken by SNS ICE/6G-IA towards the implementation of MoUs

SNS ICE and the 6G-IA board, where many of its members participate, very actively work towards the implementation of the MoUs listed in Section 3.1. A non-exhaustive list of recent activities conducted by SNS ICE/6G-IA can be found below these lines. For further details the interested reader is referred to Section 4 and 3.2.2 ahead, and other sections in SNS ICE's deliverable D1.1.

- **Next G Alliance/ATIS:**
  - Call for proposals for collaboration with the US in the SNS R&I Work Programmes 2023, Dec. 2022.
  - Elaboration of the joint 6G-IA/Next G positioning paper "EU-US Beyond 5G/6G Roadmap", April 2023.
  - Invited speech at the 6G world: 6G symposium Crucial conversations event and participation in a side meeting with experts, September 2024.
  - Panelists on 6G gaps and priorities in the 2024 Brooklyn 6G Summit, October 2024.
- **Beyond 5G Promotion Consortium (B5GPC):**
  - Invited speech at B5G Promotion Consortium International Conference, February 2024.
- **Taiwan Association of Information and Communication Standards (TAICS):**
  - Co-organisation of the EU-Taiwan Joint 6G SNS Workshop, October 2024.
- **Bharat 6G Alliance:**
  - Keynote by the 6G-IA on "Status of 6G Research in Europe", August 2024.
  - Panelist on international research collaboration for 6G in the Global 6G Symposium'/India Mobile Congress (IMC), October 2024.
- **IMT-2030 (6G) Promotion Group:**
  - Keynote on European-level 6G research at the Global 6G Developm. Conference-IMT-2030, Nov. 2024.
  - Organisation of 6G-IA-IMT 2030 PG online workshop, Nov. 2024.
- **6G-Platform Germany:**

[38] https://wiot.northeastern.edu/news/northeastern-university-sutd-mou-open-ran-and-6g/.
[39] https://www.ericsson.com/en/press-releases/5/2024/ericsson-research-and-turkcell-sign-mou-at-mwc-2024-for-6g-research-and-development.
[40] https://www.mediatek.com/tek-talk-blogs/mediatek-and-singapore-university-of-technology-and-design-sutd-sign-mou-on-6g-technology-research-collaboration

  - Keynote speech at the yearly Berlin 6G Conference 2024 organised by 6G Platform, July 2024.

- **Association for European nano-electronics activities (AENEAS):**
  - Participation of AENEAS representatives in the workshop on research priorities on microelectronics for 6G, Oct. 2023.
  - Participation of AENEAS representatives in the workshop on research priorities on signal processing and wireless technologies for 6G, April 2024.
- **European Telecommunications Standards Institute (ETSI):**
  - Co-organisation of EUCNC'24 workshop on "How to accelerate 6G research through global standards", June 2024.
  - Program committee member, presenter and panelist at ETSI's workshop on Software and Standards for Smart Networks & Services, Nov. 2024.
- **5G Media Action Group (5G-MAG):**
  - Organisation of 6G-IA and 5G-MAG Joint Workshop on “Media Beyond 5G – Insights from European Projects, May 2024.
- **5G Alliance for Connected Industries and Automation (5G-ACIA):**
  - Joint participation in panel discussion on "Why 6G: The European Priorities" in 5G Techritory, Oct. 2024.
  - Invited presentation on 5GPPP/SNS Trials & Pilots activities at the 5G-ACIA yearly meeting, Dec. 2024.
- **Alliance for Internet of Things Innovation (AIOTI):**
  - Elaboration of the 6G-IA & AIOTI White Paper The role of 6G in agriculture, May 2024.
- **ScoDIHNet:**
  - Chairmanship of the ScoDIHnet sub-WG of the 6G-IA Trials WG. Since January 2023.

3.2 SNS ICE/6G-IA’s approach to consensus building

The overall approach of SNS ICE to consensus building was presented in deliverable D1.1, where via international and European collaborations, as well as via key position statements and publications, SNS ICE partners promote the European positions and the work carried out within the SNS-JU, while at the same time engage in meaningful conversations to identify commonalities and differences with other global regions and key stakeholders. In this section, the relevant updates will be reported in terms of key contributions from SNS-JU and 6G-IA to the global 6G community, important collaborations with other regions and R&I programmes and the undertaken efforts to foster synergies among key stakeholders, which in turn help shape the future of the SNS-JU R&I Work Programme.

3.2.1 Key Strategies for 6G: 6G-IA 6G position paper v2.0

SNS ICE members hold key positions within the 6G-IA (Governing Board members, 6G-IA office members, etc.) and as such are working tirelessly to combine the vision with of the European private sector with the global trends and align with the strategic European positions and policies on Digitalisation and Future Networks. Several SNS ICE members participated in the core team of editors on the recently updated **6G-IA Vision Paper**[41] (November 2024), where they brought in the stimuli collected from the different SNS ICE activities, namely ideas and trends from other global regions, roadmaps of other EU associations and R&I programmes and priorities collected from key stakeholders based on interactions from SNS ICE events. As such, the updated 6G-IA Vision paper, brings forth the 6G vision of the EU private sector, but it remains well positioned and balanced with

[41] https://6g-ia.eu/wp-content/uploads/2024/11/european-vision-for-the-6g-network-ecosystem.pdf

respect to the global trends and well aligned with the vision expressed by other global and European stakeholders (thanks to data and input from SNS ICE).

The 6G-IA Vision paper highlights the importance of creating a unified 6G vision, driven by key stakeholders worldwide, towards a single global consensus. Specifically, the European perspective, as represented by the 6G Smart Networks and Services Industry Association (6G-IA), is emphasised, showcasing Europe's proactive role in 6G research, development (R&D) and standardisation, also addressing societal, environmental, economic and market challenges. The paper captures the ongoing global efforts to develop and standardise 6G networks and have them ready for a commercial launch around 2030.

In the paper, the technological advancements anticipated in 6G are highlighted, such as native artificial intelligence (AI) support, integrated sensing and communications (ISAC), and advanced cybersecurity. 6G systems themselves need to be sustainable. The paper also provides an updated vision on the forthcoming 6G architecture, focusing on potential innovations and addressing current 5G limitations. Fundamental challenges in 5G that hinder efficient global operations are identified and potential architectural innovations for 6G to overcome these challenges are outlined. These innovations aim to create a robust, flexible, and sustainable network architecture capable of supporting next-generation applications and services.

Figure 14: Main building blocks of 6G Networks according to the 6G-IA Vision paper.

Figure 14 depicts the main building blocks of 6G Networks as envisioned by the EU private sector and presented in the updated 6G-IA Vision paper. A dedicated webinar[42] to present the white paper to the SNS community and the rest of the world was held on November 25th, 2024. Key editors and contributors of the white paper presented the main results and insights of the paper, explaining the process and key views of the 6G-IA members, and highlighting the importance of the investigated technologies and enablers for the development of 6G networks. The event was very successful as approximately 180 people attended the event live, while dozens more downloaded the presented material and the recording of the event at a later stage. The 6G-IA, has further

[42] https://6g-ia.eu/event/6g-ia-new-vision-paper-webinar/

promoted the white paper via its members lists and LinkedIn account, while several additional accounts (SNS-JU, Hexa-X-II, peer associations, etc.) have also made announcements about the event. 6G-IA and SNS ICE members are further promoting the paper via presentations in various relevant events, where the paper is used as a primary source of information (and referenced accordingly). The publication of the paper has also been featured in all relevant newsletters and newsflashes of the SNS-JU and the SNS ICE and SNS OPS CSA projects, while special announcements have also been made to the SNS Steering Board and Technology Board.

3.2.2 Collaboration with other regions in the SNS R&I Work Programme

Collaboration in aligning or defining joint R&I Work Programmes is critical for consensus building. The primary objective is to establish a unified framework that promotes a European approach to 6G while fostering international cooperation with regions already advancing ambitious 6G initiatives. Subsequently, this consensus can be leveraged in standardisation efforts.

To date, international collaboration in the SNS R&I Work Programmes [33][34] has focused on specific regions, including the USA (Call 2023); and Japan, and the Republic of South Korea (Call 2024). These collaborations revolved around clearly defined set of mutually relevant topics.

As per the SNS R&I Work Programme 2023-24, the cooperation with the **US** focused on technologies and architectures exploring AI to facilitate (i) global validation, adoption and standardisation of intelligent approaches; (ii) a widely accepted framework for meaningful evaluation of proposed AI/ML-powered solutions for 6G networks; and (iii) technology validation in platforms. 6G-XCEL[43] (6G Transcontinental Edge Learning) was the project retained from this call which kickstarted in January 2024. The project revolves around the concept of DMMAI (Decentralised Multi-party, Multi-network AI), a reference framework for AI in 6G to pave the way towards global validation, adoption and standardisation of AI approaches. This framework is expected to enable the federation of AI-based network controls across network domains and physical layers, while promoting security and sustainable implementations. It will also enable the development of reference use cases, data acquisition and generation methods, data and model repositories, curated training and evaluation data, as well as technologies and functionalities for its use as a benchmarking platform for future AI/ML solutions for 6G networks. The consortium includes 10 partners from the EU plus 10 partners from the US. In total, 4 EU experimental platforms are being used in the project, namely, the Open Ireland Testbed, Patras5G/P-NET Testbed, SLICES RI; and the City Lab, Smart Highway and 5GOpen, 5G-in-a-box portable and Time Sensitive Networks (TSN) Testbeds. From the US side, two additional testbeds are contributed: the so-called CCI xG Testbed; and COSMOS, one of the experimental platforms funded by the NSF Platforms for Advanced Wireless Research (PAWR) programme. The project targets two distinctive use cases: DMMAI for 6G spectrum management, and AI enhanced resource management. The first set of deliverables with technical results is planned for M12 (December'24).

The collaboration with **South Korea** targets Radio Access Networks (RAN) and integrated device-network approaches. Specifically, it focuses on (i) AI/ML algorithms for the automation of base station management; (ii) base station optimisation for energy saving and network failure recovery; and (iii) the definition of an architectural framework addressing interoperability needs. From this call, the 6GARROW project which addresses 6G AI-native integrated RAN-core networks was selected. This transformative approach not only enhances the user experience by delivering higher throughput, lower latency, and improved reliability but also lays the foundation for realizing a diverse range of innovative services, including spatio-temporal, critical, compute-AI, omnipresent IoT, immersive communications, and global broadband services. The consortium includes 8 partners from the EU and 5 partners from the Republic of Korea. The project is set to start in January 2025.

[43] https://www.6g-xcel.eu

As for **Japan**, the priorities in scope include AI-enabled radio access network (RAN) solutions including physical layer and signal processing technologies, and open RAN/virtualisation. 6G-MIRAI (Machine Intelligence based Radio Access Infrastructure) was the project selected from this call. It pursues four main objectives: (i) developing reliable and robust AI-ML techniques for future wireless communications; (ii) conceiving practical AI-native design for next-gene radio access networks; (iii) establishing a common EU-JP platform for data, benchmarking, and validation; and (iv) aligning EU-JP strategies in future standardisation efforts.

No dedicated funding for international cooperation is envisaged for Call 2025 of the SNS R&I Work Programme. Yet a number of target countries were discussed in the preparation phase, this including a follow up call with the US or a new one with India, a final decision was made to postpone such initiatives for a possible consideration in a later call. This would allow a more detailed analysis in terms of cost-benefit trade-offs, alignment with technology sovereignty policies, and willingness of the peer funding agencies to support those collaborations. Instead, a lighter Work Programme-scale collaboration is prioritised, as discussed in Section 3.3.6 ahead.

3.2.3 Synergies with IPCEI-CIS and Cluster 4

As discussed in Section 2.1.4, telco cloud solutions and streamlined service deployment are of prime importance for the European telecom industry. To avoid technology dependencies and vendor lock in from the proprietary solutions provided by hyperscalers from overseas, is of utmost importance to strengthen the European positioning. To that aim, a number of initiatives are in place, namely, IPCEI-CIS, Cluster 4 activities on advanced computing and big data, and the anticipated Cluster 4 call on large scale-trials for e2e infrastructures. In addition, in the SNS R&I Work Programme 2024, there is a dedicated call for proposals on 6G telco cloud and service provision enablers under Stream C.

In the white paper on "How to master Europe's digital infrastructure needs?"[35], a coordinating role was assigned to the SNS-JU in the telco-cloud area. Consequently, substantial efforts have been spent in 2024 in building consensus and fostering synergies among key stakeholders in the IPCEI-CIS community and the European Commission (DG-CNECT). This has also led to the formation and launch of the SNS-JU Policy WG on 3C networks. Further details on such coordination/consensus-building activities can be found in Section 3.3.3.

3.2.4 Liaison with Digital Europe (DEP) and Connected European Facility (CEF) programmes

One priority of the SNS-JU is to cooperate with the other European funding programs to ensure overall consistency and avoid gaps and overlaps. To that aim, SNS ICE project has established link with the Digital Europe Program (DEP) and the Connected European Facility (CEF) program.

Digital Europe Program (DEP)

This program aims to bridge the gap between digital technology research and market deployment, focusing on three key domains: HPC, AI, cybersecurity, along with digital skills development to promote the adoption of digital technologies.

Although Smart Connectivity is not a core domain of the Digital Europe Program (DEP), the SNS ICE project focuses on facilitating 5G adoption through Digital Innovation Hubs (DIHs). Supported by 5G PPP, 6G-IA, and AIOTI, the SCoDIHNet initiative aids DIHs in their operations by providing services, catalogs, and platforms.

During the SNS ICE project, efforts have centered on defining five key services, including a Technology & R&I Info Hub, designed to clarify technological associations (e.g., AI in Industry 4.0) and dependencies to establish a shared understanding. This involves concrete actions such as technology updates, use case reviews, and matching solutions to challenges. SCoDIHNet's replicability initiative supports the adoption of SNS project outcomes by enabling DIHs to leverage a catalog of replicable use cases for real-world applications.

Additionally, SNS ICE and SCoDIHNet organize webinars and podcasts to foster collaboration between DIHs and technology providers involved in SNS projects.

Connecting European Facility (CEF) program

The Connecting Europe Facility – Digital (CEF Digital) supports investments in safe, secure, and sustainable high-performance digital infrastructure, with a focus on Gigabit and 5G networks across the EU. Key initiatives include the deployment of 5G Corridors and 5G for Smart Communities.

6G-IA oversees several working groups, including one dedicated to 5G/6G for Connected Automated Mobility (CAM). This group serves as a hub for knowledge and collaboration on CAM-related connectivity, emphasizing 5G and future technologies. It brings together participants from European Commission-funded R&I projects focusing on CAM use cases and deployments.

A core objective of this group is the development of the 5G Strategic Deployment Agenda, used by HaDEA to design CEF calls for the 5G Corridors sub-program. Additionally, 6G-IA contributes to the GUIDE support action, which facilitates the 5G Corridors projects by identifying best practices to accelerate solution replication across TEN-T road, rail, and waterway corridors.

The SNS ICE project, in collaboration with GUIDE, organised a webinar on Automotive, Transport, and Logistics. The event highlighted ongoing CAM-related activities within SNS-JU projects and the CEF program, while also sharing insights and priorities from key automotive stakeholders.

3.3 Contribution to future SNS R&I Work Programmes

In 2024, the SNS ICE project has also made substantial contributions towards the definition of a consensual SNS R&I Work Programme. To that aim and in close collaboration with SNS OPS, a number of workshops were organised in Brussels in April. The ultimate goal was to build consensus among key European players on their research priorities in five distinctive areas, namely, (i) Wireless technologies and signal processing; (ii) non-terrestrial networks; (iii) Telco cloud and service provision; (iv) Photonics; and (v) Security. This bottom up approach is in stark contrast with the methodology followed in previous years where the definition of the SNS R&I Work Programme was largely based on NetworldEurope's Strategic Research and Innovation Agenda (SRIA). Key players of the SNS-JU were invited to attend the aforementioned workshops, this including equipment vendors, mobile network operators, SMEs, research centres and universities. Notably, many of those equipment vendors and mobile network operators are, in fact, global players. Hence, this series of workshops, yet indirectly, can also be regarded as a contribution to global consensus towards a single 6G standard. In subsequent sections, we outline the main conclusions obtained in the workshops (Sections 3.3.1 to 3.3.5). Next, in Section 3.3.6, we summarize the main changes in the SNS R&I Work Programme 2025 stemming from the organisation of those events.

3.3.1 Wireless Technologies and Signal Processing workshop

In upcoming calls of the SNS R&I Work Programme, the participants to this workshop recommended that priority should be given to a number of topics which are technologically relevant, timely and aligned with upcoming standardisation work. This includes the following areas [39]:

- Physical layer technologies for enhanced spectral efficiency
- Extreme exploitation of MIMO technologies
- AI/ML and semantic communications
- Spectrum sharing and RAN co-existence
- Automation and disaggregation in the RAN segment
- Network as a sensor and positioning
- Use of multi-processor SoC/accelerators and flexible HW architectures

Sustainability was also identified as a priority. Given the large contribution of radio access networks to the overall energy consumption of wireless networks, this should be regarded as a horizontal aspect to be addressed by the aforementioned topics/priorities to the largest extent possible.

Several companies expressed their interest in conducting research activities in the upper mid-band (FR3) given the inherent cost vs. spectral efficiency trade-offs, and their suitability for technologies such as JCAS/ISAC and ultra/massive MIMO evolutions. This is despite the large interest that sub-THz, THz and mmWave communications raised in the first calls of the SNS-JU. However, the support of the big industry players participating in the workshop is more limited now, at least in the short term.

In addressing the aforementioned topics, particular attention should be paid to the gap analysis in the current SNS project portfolio, and to the corresponding TRL levels of such technologies. It was also noted that part of the research under multi-processor SoC/accelerators and flexible HW architectures go well beyond the scope of SNS (e.g., RAN silicon, energy-efficient ASIC technology). Whereas SNS projects are likely to leverage and/or integrate those technologies, their development clearly falls under the umbrella of the Chips JU. Currently, SNS' Front-End Module (FEM) initiative, which is aimed at establishing synergies with the Chips JU, does not cover those aspects. Therefore, one possible way forward would be to address those developments as part of the Chips JU efforts. On the contrary, research on efficient support of mmWave and sub-THz communications and RF technologies for FR3 implementation could make a better fit into the FEM initiative or, alternatively, in selected parts of the CJU Work Programme in relation with e.g., its cross-sectional technology 2.2 (Connectivity) in the ECS SRIA.

3.3.2 Non-terrestrial networks workshop

The systems considered by the industry are based on multi-orbit constellations. The target is to have these constellations seamlessly interoperable with terrestrial networks, 5G and then 6G, for the provision of fully integrated end to end services and for the services that are compatible with the specificities of systems in orbit. The priority set forth for the Work Programme was to work on unification of satellite and terrestrial systems, meaning that the same technologies can be used for both terrestrial and satcom systems, with the possible tuning of common parameters. This goes beyond the integration approach that has already been successfully developed at 3GPP level in the 5G context. A key benefit of this approach is to fully benefit from the 3GPP ecosystem with its economies of scale and of scope. This complements the specific services that can natively be delivered by satellite like coverage extension. In this context, some use cases are of key importance to design the future systems, and notably PPDR and aeronautic usages, which have very high-performance requirements. Supporting this vision requires availability of a multiplicity of technologies.

A number of system-level technologies were identified, requiring a strong partnership between the space and terrestrial communication communities. It was hence decided to focus on these topics for SNS actions. The following topics were identified to cover in Work Programmes 2025 and beyond as follows [38]:

1) Management of multiple access networks through unified Control Plane capable of optimizing TN-NTN service provision.
2) Dynamic routing in multi-dimensional networks with selection of optimal paths for traffic, which is a key feature in leveraging the potential of NTN-TN integration
3) AI Based end to end resource control, orchestration and management, with seamless TN-NTN resource management capabilities.
4) Spectrum issues including i) novel schemes for dynamic spectrum access and sharing in FR3 (7 – 24 GHz), providing good cost-coverage trade-off; ii) possible dynamic reuse of TN frequencies for NTN use where TN spectrum not used
5) Multi tenancy and end to end resource slicing capabilities across multiple tenants.
6) Integrated communication and positioning, GNSS free operations, study of various architectures (Network, UE, multiple satellites, etc.); integrated communication and sensing.
7) Multi access capabilities and carrier aggregation
8) Autonomous and self-configuration of NTN resources and stability vis a vis TN resource management and control.

From the above list, it was concluded that topics #1, #2, #4, and #5 would have the higher priority. They are hence reflected in the WP 2025 for the NTN work. Topics #3, #6, #7, and #8 are considered for follow-up actions

that could form the basis of the future WP 2026. It was also decided to follow up in 2026 to potentially move the technologies into the demonstration phases using ESA satellite demo capabilities.

Other space-specific technologies were also discussed and identified at the workshop. These include typical R&I topics such as inter-satellite links, distributed massive MIMO generated by swarms of satellites, regenerative on-board payloads, low cost flat panel antennas (VSATs), open hardware, quantum payloads, high frequency antennas (Q/V bands), in orbit SDN controllers, propagation models, etc. The discussion showed that these topics are significantly covered by several EU space agencies and that the required budget to develop such low volume technologies would not be compatible with the SNS budget envelope. It was consequently decided not to cover these topics in depth in the SNS context.

3.3.3 Telco cloud and service provision workshop

The outcome of the IAFA on **telco cloud** and **service provision** provided with a plan for SNS R&I activities based on the following key priorities [40]:

- Minimize the dependencies from the Hyperscalers for the European stakeholders,
- Rely on open-source solutions to reach faster the target of European wide accepted solutions,
- Target the standardisation of the results so that future solutions will abide to the European rules for security, privacy, sustainability etc.
- Identify synergies among European funding instruments to maximize the impact of their activities and shorten the delivery of well-studied and tested solutions,
- Solutions should Investigate efficient implementations of regulations (EU data act, EU AI act, CRA, etc.).

As discussed in Section 2.1.4, apart from the SNS-JU activities in this area, one needs to consider related activities in:

- the IPCEI-CIS
- the Cluster 4 activities on advanced computing and big data
- the anticipated Cluster 4 call on large scale-trials for e2e infrastructures

The IPCEI-CIS initiative aims to achieve the “first industrial deployment (FID) of software components to establish and operate a distributed, openly accessible, and interoperable EU Multi-Provider Cloud-Edge Continuum.” Similarly, Cluster 4 activities on advanced computing and big data are developing modern IT platforms for a cognitive cloud-edge computing continuum. Meanwhile, future SNS-JU calls and an anticipated Cluster 4 call on large-scale trials for end-to-end infrastructures are under preparation.

To develop a realistic and synergistic plan, it is essential to align with the timelines of these initiatives. The IAFA plan on telco cloud has accounted for this, offering a possible way forward and identifying potential synergies among the various efforts. This plan has been discussed with the IPCEI-CIS community and the European Commission (DG-CNECT) and has informed the SNS-JU Policy WG on 3C networks. This working group is tasked with creating the official SNS plan, where the SNS-JU could play a coordinating role among related initiatives.

3.3.4 Photonics workshop

This workshop [37] provided a plan for SNS research and innovation activities with the following priorities based on the approach that networking related topics are addressed in SNS and components are in scope of Photonics 21:

- Higher speed and capacity optical access networks and future end-to-end packet optical network architecture in all network domains including backhaul use cases and potentially for optical space links in NTN systems, where the components and systems are developed in other initiatives but integrated in SNS platforms.

- Integration of high performance and highly efficient passive optical network based on various technologies.
- Integration of photonics and wireless systems including sensing.
- Protocols for the future end-to-end packet optical network architecture by considering adaptive multiband optical transmission, open and disaggregated optical networks.
- Quantum networking over fibre for trustworthy systems and applications.
- Impact of photonic systems in 6G on energy consumption / sustainability.
- AI enhanced green optical networks and systems and AI enabled optical network automation as well as optical sensing for environment and networks.
- Enhanced trustworthiness with security enhancement and increased resilience.

Sustainability is addressed in most priorities due to the low energy consumption of wideband photonics systems.

There were also other contributions ranging from components, photonics signal processing and implementation technologies to optical network architecture. However, it was agreed between workshop participants that Photonics 21 is focusing on components development and technology and SNS research and innovation activities on system aspects of optical networks and their integration in the overall 6G architecture. The workshop results were contributed to the preparation of the SNS Work Program 2025 and are well represented.

3.3.5 Security topics workshop

The outcome of the IAFA on the security topics outlined technical priorities for a strategic approach to 6G security research and innovation. The experts recognised the critical role in building a secure and trusted next-generation digital infrastructure. The topics for consideration were organised in four areas, namely Architectures, Operations, Services and Evaluation, which have been further broken down into several promising fields of research as follows:

- **Secure 6G Architectures:** Zero-trust integration including confidential computing; Integration with ISAC Integration with PQC and QKD; Cloud, IoT, and Beyond.
- **Automation and intelligence in Security Operations**: Detection & Response in 6G with secure AI, Full-6G Resilient Infrastructure & Services, 6G security knowledge and cooperative mechanisms.
- **Secure Services & Security services:** User-Centric Security in 6G, Intent-Based Security, Collaboration for a Secure Ecosystem.
- **6G Security Evaluation:** Continuous Security Assessment, Standards for Security Quality, Security Measurement and Certification.

The full list of prioritised topics along with related contributions from the SNS and Photonics21 communities can be found in the WS report which is available at [36]. Additionally, the report outlined the following important considerations.

- **Holistic approach to security**: While certain 6G security vulnerabilities may manifest at the physical layer (radio or optical), true security demands a holistic approach. Jamming detection, for example, necessitates countermeasures beyond the physical, potentially leveraging intelligent reflecting surfaces (RIS) and AI-based management for optimal network defence. Similarly, research on physical layer fingerprinting could inform broader actions like blacklisting suspicious devices.
- **Hardware (HW) security**, including potential root of trust coming with confidential computing may be handled through dedicated programs or at least with a fraction of it dedicated to 6G.
- **Synergies with other programs**: 6G being at the crossroad of multiple technologies and architectures, there are several opportunities to collaborate and optimize synergies in the following areas: (i) security of cloud

continuum/6G with corresponding existing IPCEI and/or other HPC HE/DE initiatives; and (ii) AI and Data Security including regulations

- **Role of quantum technologies**: Quantum topics and quantum technologies integration may be handled through existing flagships and initiatives
- **Liaison with European Cybersecurity Competence Center**: 6G security has specific application of numerous security topics which fit under the umbrella of the European Cybersecurity Competence Center (ECCC). It is strongly recommended to reinforce synchronize the actions in research and Innovation (both HE and DE) and even beyond for regulation/certification.

3.3.6 Main changes in the SNS R&I Work Programme 2025

The high-level structure of the SNS R&I Work Programme 2025 remains, to a large extent, unaltered with respect to previous releases. It continues to revolve around three streams, namely, Stream B covering research for revolutionary/evolutionary technology advancements for 6G; Stream C, which focuses on further development and consolidation of experimental infrastructures; and Stream D, targeting 6G SNS Trials and Pilots with verticals. Content-wise, however, it incorporates a large number of innovative aspects and enhancements which follow from the definition of new EU policy objectives (e.g., in relation with technological sovereignty and protection of critical communication infrastructures [35]), the start of 6G standardisation activities in 3GPP in 2025 (see Section 2.1.3.1) ; and the conclusions drawn and technical priorities identified in the SNS workshops with key stakeholders organised in Brussels in April 2024 (see Sections 3.3.1-3.3.5 above). Specifically, the main changes in the SNS R&I Work Programme 2025 include the following:

- **Reinforced interest in standardisation impact and proof-of-concepts activities**: Differently from Calls 2022 and 2023, and in line with Call 2024, Stream B projects are designed to deliver more advanced and higher-TRL outcomes, such as PoCs, with the potential to significantly impact standardisation activities. Additionally, the Stream C project, now focused on 6G telco-cloud (see below), is expected to influence existing or emerging open-source initiatives and standardisation efforts, particularly within ETSI. Similarly, Stream D projects are intended to support contributions to standardisation bodies, with an emphasis on 6G use cases, technologies, and KVIs.
- **Exploration of disruptive 6G technologies *beyond* 2030**: Stream B is also tasked with the exploration of technologies at a very early stage of research (starting at TRL 1-3, and reaching TRL 3-4 by the end of the project) but, still, with some prospect to become part of new advanced systems. This includes advanced architectures systems and technologies (e.g. goal-oriented communication strategies); and disruptive IoT and device technologies (e.g. close to zero-energy devices). This will be accomplished via a number of smaller projects under Stream B-01 that, unlike in previous Work Programmes, is not focused on 6G architectural aspects given the immediate start of standardisation work at 3GPP.
- **Introduction of a dedicated project on 6G telco cloud and service platforms**: The goal here is to create an R&D 6G telco cloud pan-European platform combined with service provision enablers that can be used to test and experiment with candidate 6G technologies and enablers. In line with 3C Networks orientations, it should help mitigate the market dominance of non-EU solutions and, by doing so, strengthen technological sovereignty. The project, under Stream C, should rely on existing or new open-source efforts under GSMA (e.g., Open Gateway), and open-source projects (e.g., Sylva). The project, which is forward-looking and expected to reach TRL 5 at the end, is designed to complement other initiatives like the Cluster 4 call on large-scale pilots for telco edge cloud (higher TRL, focus on 5G systems); and IPCEI-CIS, targeting to deliver operational solutions.

- **Launch of the Front-End Module (FEM) initiative**[44]: The 2025 Work Programme includes a project focused on designing a comprehensive FEM, incorporating a digital front-end and a radio front-end with antenna elements and the required conversion stages. The project prioritizes support for the upper mid-band (FR3), identified as a key industry focus, alongside FR1 and FR2 bands, while excluding developments in frequencies beyond 71 GHz. This initiative, potentially **extends** into future Work Programmes, aims to transition to validation within the Chips JU Pilot lines, paving the way for European product development and mass-market adoption. It builds upon and complements the Microelectronics projects and the Microelectronics Lighthouse project from SNS Calls 2023 and 2024, respectively.
- **Re-focusing of trials & pilots projects with verticals**: Unlike in previous Work Programmes, Stream D projects in the 2025 call are not intended to be large-scale initiatives. Instead, they are expected to concentrate on specific vertical sectors (typically one, or at most two), defined use cases, and a limited number of locations. The primary focus of these projects should be on experimental validation and supporting the monetisation of 6G services and applications for verticals. Selected use cases must align with the European vision and priorities outlined during the 3GPP SA1 Workshop held in May 2024. Projects should leverage platforms and components developed in earlier SNS initiatives (Streams B, C, and D) or national projects, with upgrades applied as needed.
- **No dedicated calls for international cooperation**: As discussed in Section 3.2.2, no dedicated call for international collaboration is planned for 2025. Instead, in Stream B projects with inclusion of US subsidiaries, it is expected to establish cooperation and provide wide visibility of the related undertaken R&I, notably how the work relates to the related US developments under the Next G Alliance.
- **Fostering the unification of terrestrial and non-terrestrial networks** by achieving a deeper level of integration beyond the system integration accomplished in 3GPP. Wherever feasible, this should involve reusing common technologies, architectures, protocols, and interfaces across both terrestrial and non-terrestrial segments. The approach should address the stringent requirements of innovative use cases, such as Direct-to-Device and PPDR.

3.4 Key insights based on SNS ICE analysis

The evolving global 6G ecosystem has gained momentum, largely driven by a network of MoUs that reflect not merely agreements on paper but active, collaborative action plans. At the heart of this initiative in the EU context is 6G-IA, which through the **SNS ICE project has been instrumental in crafting and implementing European-driven MoUs** that establish robust frameworks for cooperation **across research, industry, and diverse vertical sectors**. These European MoUs are rooted in the EU's commitment to technological leadership and sovereignty, involving key partnerships with organisations like the European Telecommunications Standards Institute (ETSI), the European Space Agency (ESA), and the 5G Automotive Association, among others, fostering alignment in research agendas, standards development, and innovation pathways.

Beyond Europe, the ecosystem extends into a mature, truly international and intercontinental network of collaborations. MoUs with global players like the Next G Alliance (USA), Beyond 5G Promotion Consortium (Japan), and Bharat 6G Alliance (India) highlight a worldwide commitment to harmonising research in telecommunications, aligning regulatory policies, and co-developing standards for 6G. These partnerships reflect a broad geographic reach and thematic diversity, encompassing regions as varied as North America and Asia. An overarching emerging trend is the **clear push toward achieving a unified global 6G standard**, with several organisations coordinating closely on spectrum policy, architecture, and societal impact considerations, ensuring interoperability across regions and fostering a resilient international 6G ecosystem. Additionally, these MoUs increasingly emphasise the **integration of advanced technologies like AI, quantum computing, and non-**

[44] The introduction of this initiative follows from an additional workshop organized by 6G-IA in Brussels in October 2023 that was aimed to identify research priorities on microelectronics for 6G networks R&I activities. The workshop was reported in SNS ICE deliverable D1.1. The workshop report can be found here: [41]

terrestrial networks (NTNs) to support both terrestrial and satellite-based connectivity. Another key trend involves expanding **joint research efforts, workshops, and trials to synchronise advancements and share insights**. This collaboration aims to build secure telecommunications networks and resilient supply chains to address the growing demand for digital inclusion and sustainable connectivity solutions.

Beyond the formal importance of MoUs, **the SNS ICE project has worked to translate these MoUs into concrete activities**, such as workshops, collaborative research initiatives, and standard-setting processes. These efforts are not only advancing 6G innovation but also reinforcing pre-existing alliances, such as those established during the 5G era while addressing new opportunities and challenges unique to 6G. The resulting ecosystem is both dynamic and inclusive, encompassing diverse stakeholders and paving the way for a globally harmonised approach to next-generation networks. This vibrant ecosystem exists with or without the participation of these leading organisations, underscoring the universal commitment to realising a connected future, but the role of SNS ICE and 6G-IA in shaping this vision remains pivotal.

Another key element of the global 6G ecosystem's success lies in its approach to **consensus building, spearheaded by 6G-IA through publicly available position papers and roadmaps that articulate Europe's vision for 6G**. These position papers act as platforms for disseminating Europe's stance on key technological, societal, and environmental challenges while fostering dialogue with international stakeholders. They highlight technological advancements and innovations to overcome 5G's current limitations and promote transparency and collaboration, encouraging the convergence of ideas and objectives across continents. The papers' widespread dissemination through multiple online channels and presentations in international fora ensures that Europe's vision for 6G is accessible and contributes to shaping a unified global consensus, reinforcing Europe's efforts within a broader, interconnected framework of innovation and progress.

The **integration of international research and innovation (R&I) collaborations into the SNS R&I Work Programmes** constitutes another significant step forward in embedding global cooperation into the European 6G agenda. Despite challenges, such as aligning priorities and synchronizing activities with non-European partners, these collaborations aim to shape a unified framework that combines European leadership with global advancements. Projects like 6G-XCEL, 6GARROW, and 6G-MIRAI exemplify this effort, bringing together partners from Europe, the US, South Korea, and Japan to address critical areas such as AI-enabled RAN, sustainable network architecture, and intelligent spectrum management. These initiatives reflect the ongoing commitment to overcome barriers and establish a robust international presence, fostering innovation and standardisation that benefits all stakeholders. A key focus of these efforts is **boosting European competitiveness against non-European hyperscalers, ensuring that the EU retains technological sovereignty** in the face of significant competition. Initiatives like the IPCEI-CIS and activities under Cluster 4, alongside dedicated calls within the SNS R&I Work Programme, are designed to reinforce Europe's position in advanced computing, telco-cloud solutions, and large-scale infrastructure trials. These efforts align with broader European strategies to reduce dependence on proprietary overseas technologies. Additionally, **coordination with programs like Digital Europe (DEP) and the Connecting European Facility (CEF)** reinforces the coherence of Europe's digital infrastructure strategy. By establishing meaningful dialogue with DEP's focus on digital innovation hubs and CEF's emphasis on 5G corridors and smart communities, the European 6G ecosystem is becoming more comprehensive and interconnected. This cross-program alignment ensures that European initiatives in connectivity, automation, and mobility are supported by robust funding and strategic frameworks.

Finally, attempts to foster cooperation among a wide set of stakeholders are also witnessed by the way in which the 2025 SNS Work Programmes were conceived. Unlike previous version emerging from the Strategic Research and Innovation Agenda (SRIA) edited by NetworldEurope, the **series of workshops organised to inform the 2025 R&I WP edition marked a significant shift toward a bottom-up approach**, allowing stakeholders within 6G-IA to shape the priorities of the Work Programme. The choice of such a consultative process ensured that the final program closely reflected industry and research community needs on a variety of topics. Ultimately, the workshops fostered consensus on key areas such as spectrum management, AI-enhanced network automation, sustainability, and the deeper integration of terrestrial and non-terrestrial networks.

Notably, **the recommendations emerging from these workshops directly influenced the updated structure of the Work Programme**, integrating new priorities in the SNS R&I Work Programme. A key outcome was the need to deliver higher Technology Readiness Level (TRL) outcomes, ensuring that research projects contribute directly to standardisation efforts and pave the way for real-world applications. This approach reflects the growing need to bridge the gap between research and practical deployment, particularly in AI-powered network management, integrated sensing, and advanced spectrum utilisation. The Work Programme also focuses on disruptive technologies aimed at systems beyond 2030, signalling a forward-looking strategy to maintain Europe's technological edge in the evolving global 6G landscape. Another major enhancement is the inclusion of a Front-End Module (FEM) initiative, prioritising development in the upper mid-band spectrum (FR3), which is seen as critical for achieving cost-effective spectral efficiency and supporting advanced technologies like joint communication and sensing (JCAS) and massive MIMO evolutions. Finally, the Work Programme introduced a different approach to trials and pilots within vertical industry domain, concentrating on experimental validation within specific sectors, such as Public Protection and Disaster Relief (PPDR) and Direct-to-Device communications.

4 International workshops and events

4.1 Global 6G event at Techritory 2024

5G Techritory has become a premier platform for advancing 5G deployment and digital transformation across Europe, serving as a unique meeting place for decision-makers, industry leaders, and policymakers. The forum fosters collaboration across borders, sectors, and levels, addressing the most pressing challenges and opportunities in the 5G and beyond-5G ecosystem. Attracting over 2000 participants and 100+ world-class speakers annually, 5G Techritory facilitates meaningful dialogue and action among stakeholders shaping the future of connectivity. Since 2018, 5G Techritory has slowly but steadily grown into an international platform, bringing together over 10,000 visionaries from around the world and becoming more than an annual event, fostering cross-border and cross-industry collaboration throughout the year.

Rooted in Latvia, 5G Techritory holds particular significance for the Nordic-Baltic region, a global leader in digitalisation. The event underscores the region's commitment to innovation embracing ambitious digital development strategies that leverage 5G technologies to accelerate societal and economic transformation.

The forum is organised by VASES, with strategic support from SNS ICE partners and other key stakeholders who contribute to its global outreach and impact. 5G Techritory not only showcases regional leadership but also aligns with European and international priorities, creating a collaborative ecosystem for technology adoption, policy alignment, and cross-sectoral innovation.

A full list of the sponsors and partners can be found on 5G Techritory website as well as in Appendix 1.

4.1.1 A bird’s eye view of 5G Techritory 2024

The event was held on October 30-31, 2024. This year’s topic, “Technology Shaping Tomorrow’s Territory,” focused on extracting real value and tangible results from the program. This is partly due to the focus on co-creation events, which bring together leading practitioners to dive into workshops, ideation, and creation events throughout the forum. More than 20 co-creation events were organised, some of which include:

- **From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors** – discussions on the first 6G use cases, trends in vertical sectors, the evolution of 5G to 6G, and more
- **Horizon Europe Digital Technologies brokerage event** – info, pitching, and matchmaking session to match scientists/researchers with entrepreneurs to spot opportunities for future collaboration
- **The Quantum Technology Landscape co-creation event** – exploring national quantum initiatives and regional synergy and how regional networks can work to accelerate the pace of quantum advancements
- **The importance of GNSS Security & Resilience** – the impact of jamming and spoofing on military and civilian assets, migration strategies for integrators, and the importance of GNSS simulation for securing military applications, including hypersonic weapon systems

The event also comprised an immersive XR experience, an after-hours networking event, and countless panels and discussions, which had a focus on the most relevant topics of the day, including AI, dual-use technologies, quantum technologies, digital twins, 6G, and more.

Here's what this year's forum looks like in numbers:

- 1.800+ participants
- 803 on-site attendees
- 40 countries with on-site attendance, 77 in total
- 108 speakers
- 20 media representatives welcomed on the forum (13 foreign representatives)
- 4 media tours
- 26 panel discussions and keynote speeches

- 22 co-creation events
- 200+ media publications in two months
- 12.430 website visitors in two days
- Huge funding announcements, speeches from Ministers, European Metacities Partnership Memorandum of Understanding signed, Microchip memorandum to be signed by December 3
- Several formal and informal networking events hosted

Figure 15: Facts and figures about 5G Techritory 2024.

These are just several themes that were discussed during the forum. The full 5G Techritory forum program can be found here on the event's website.

Other achievements of the 5G Techritory 2024 are summarised in Figure 16 below.

Figure 16: Main achievements of 5G Techritory 2024.

5G Techritory 2024 was proud to host an exceptional line-up of over 100 speakers, bringing together some of the brightest minds and most influential voices in the 5G and digital innovation ecosystem. These experts,

representing diverse industries, governments, and academic institutions (see examples of key featured speakers in Figure 17 below), played a pivotal role in driving the meaningful discussions and knowledge-sharing that define the forum. Their insights and contributions were instrumental in exploring critical topics, from technological breakthroughs to policy developments and cross-sectoral collaboration. The success of 5G Techritory 2024 would not have been possible without their dedication and expertise, and we extend our deepest gratitude to each speaker for helping to shape the future of connectivity and digital transformation.

Figure 17: Featured speakers of 5G Techritory 2024.

4.1.2 Marketing and promotional activities carried out by 5G Techritory team

In 2024, together with partners 5G Techritory event generated **more than 200 publications** in local and international media – releases, opinion pieces, and interviews.

The event was widely covered in international media such as IoT Insider (United Kingdom), Ground News (Canada), The Baltic News (Baltic states), The Fast Mode (Singapore), Zpravy Kurzy (Czech Republic), Telecom Lead (India), Cyprus Shipping News (Cyprus), Presse portal (Germany), Tele Samana (Latin America), Webtime Medias (France), Trust IT (Italy), Developing Telecoms (Europe), EE World (USA), Aftonbladet (Sweden), Haufe (Germany), and others.

The event also attracted the attention of many Latvian media, including LETA, TV3, LTV, TV24, Radio Skonto, Radio TEV, LR1, LR4, Delfi, Dienas Bizness, lsm.lv, nra.lv, la.lv, Kursors, journal IR, and others.

Digital marketing campaigns were created in four channels: Google (Search, Display Affinity, In-market Audience), YouTube (Video), Facebook and LinkedIn (campaigns and sponsored posts).

The campaign focused on registration with its main aim: 400 on-site registrations and at least 1500 total registrations. It run from September 16 until October 29, 2024.

Campaigns were more active and dynamic as the conference approached, emphasizing the urgency and the fact that the number of on-site seats is starting to dwindle. Different channels were tested and compared for a balance between lower cost and target audiences. When analysing and reviewing the results, the budget was shifted to the better-performing campaigns and channels, based on website traffic, cost-per-clicks, and registration dynamics. As a result, fewer ads were shown on LinkedIn, but the most on Facebook.

The main target countries for those campaigns were Austria, Switzerland, Czech Republic, Germany, Denmark, Estonia, Finland, Croatia, Hungary, Lithuania, Latvia, Norway, Poland, Sweden, Slovenia, Slovakia.

In response to registrations and newsletter subscribers, such countries as the Czech Republic, Turkey, Greece, Belgium, and the USA.

4.1.3 Activities carried out by SNS ICE

This year, SNS ICE participated actively in one panel discussion, three co-creation events, and showcased SNS funded projects in the ICE showroom.

In-depth discussions via the panel on the topic, **"Why 6G: The European Priorities"** highlighted essential objectives for 6G systems and services across technology, use cases, and socio-economic impacts. These discussions also reviewed lessons from the development and deployment of 5G, which will guide the research, innovation, and rollout stages of 6G. Additionally, the importance of sustainability—environmental, societal, and economic—was emphasised as a core consideration in advancing 6G networks and services.

The project also organised a co-creation event to address sector needs and promote early 6G adoption: **"From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors"**. This interactive session provided insights on industrial sectors and how they plan to adopter new 6G functionalities to support digitalisation, new production paradigms and innovative business models for products and services.

Complementarily, a co-creation event to represent the European National initiatives and the Smart Networks and Services Joint Undertaking (SNS-JU) entitled **"Synergies between National 6G Initiatives and SNS-JU"** was organised by SNS ICE. The goal of this session was to identify opportunities for synergies among National Initiatives and the SNS-JU activities.

To promote diversity and inclusion and to create awareness on the topic, the project also organised a co-creation event on **"Shifting the Balance: Advancing Diversity in Telecoms R&D"**. The call to action from this session was to incorporate gender dimensions into sustainability strategies, while designing 6G networks. This addresses social issues such as digital inclusion, equitable access to technology, and the creation of sustainable digital economies that benefit all.

Besides, the glimpse of SNS magic was seen in the **"SNS ICE showroom"**. The team at the venue had a chance to interact with 50+ stakeholders from industry, academics and representatives of both the public and private sectors. SNS ICE showroom was one place of glimpse of activities from SNS-JU funded projects.

The SNS ICE organised sessions in Techritory 2024 are summarised in Table 8 below. Further details on their rationale, activities and conclusions can be found in subsequent sections.

Table 8: Overview of SNS ICE organised sessions at Techritory 2024.

Date / time	Type of activity	Title of the session	Speakers
31/10/24, 10:30 - 11:30 Policy and Strategy Stage	Panel discussion	Why 6G: The European Priorities	C. Willcock, 6G-IA A. Boubendir, Airbus J. Schwoerer, Orange A. Mueller, Bosch M. Achouche, III-V Lab A. Díaz-Pinés, EC
30/10/24, 14:00 - 17:00 Room K	Co-creation event	From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors	Representatives from TrialsNet and Target X projects, SNS-O, Trust-IT, GSMA, XGMF, NEC Corp, Ericsson
31/10/24, 13:30 - 16:30 Room K	Co-creation event	Synergies between National 6G Initiatives and SNS-JU	Representatives from SNS-JU/6GIA board,

			SNS-O, and National Initiatives.
30/10/24, 11:00 - 13:00 Room K	Co-creation event	Shifting the Balance: Advancing Diversity in Telecoms R&D	P. Mohnani, EURESCOM P. Sachdeva,TNO M. Giuffrida,Trust-IT L. Sarma, RigaTech girls A.Olovna,TET R. Bīrons,TET
30-31/10/24, all day Room L	Showroom	SNS ICE showroom	N/A

4.1.3.1 SNS ICE / 6G-IA Panel: Why 6G: The European Priorities

For a second year in a row, the SNS ICE coordinator, 6G-IA, organised a panel of experts from industry, regulatory bodies and associations to discuss key questions behind the development of 6G Networks. As last year's event was one of the most well attended panels of the entire conference, SNS ICE partners and the 6G-IA attempted to take things one step further and to dive deeper into concrete questions with regards to the expected use of 6G, the societal and economic needs that it should cover, the most prominent areas of applications and more. By synthesizing a diverse panel comprised by experts of different backgrounds, representing industries and associations with prominent roles in the uptake of novel technologies, this panel shed some light on the "user's perspective". More specifically, the experts of the panel were invited to weigh in on aspects such as:

- Why do we need 6G and which services will it enable?
- What are the European priorities for the development of 6G systems and services when it comes to technologies, use cases and societal/economic aspects?
- What lessons can we learn from the development and deployment of 5G networks, that should be applied during the R&I and roll-out stages of 6G?
- What is the role of sustainability (environmental, societal, economic) in 6G networks and services? Is it simply about Energy Efficiency or is it much more?

From the discussion that followed, the main hopes and concerns of the various experts were highlighted and it became apparent that while there is high anticipation and hopes for the services that 6G promises to deliver, experts are also cautious in terms of its real life deployment and the actual needs that it will fulfil and, also, they stressed that the needs of the end users should be taken into account from very early on, while development and deployment should be based on the requirements of the targeted vertical sectors.

Once again, this panel was one of the highlights of the entire event as it managed to aggregate interest from multiple on-site (73 in total) and remote participants (Livestream views: 98; Post-forum listens/views until 10.12.2024: 207). Figure 18 provides a snapshot of the panel being moderated by Colin Willcock from Nokia and 6G-IA chairman of the Board (SNS ICE partner). The recording of this panel discussion can be found on YouTube[45].

[45] https://www.youtube.com/watch?v=CLtP9iVnrOY&t=3s

Figure 18: The SNS ICE / 6G-IA panel on "Why 6G" at Techritory 2024.

4.1.3.2 Co-creation event: 6G for vertical sectors

The goal of this co creation event entitled "From 5G to 6G: leveraging key trends and 5G evolutions to shape 6G for vertical sectors" was to raise awareness on 6G amongst industrial sectors to drive future adoption. The event was organised by the SNS ICE project and, specifically, by Raffaele de Peppe (TIM) and Carles Antón-Haro (CTTC), both 6GIA Board Members and, respectively, Chairman of the Vertical Task Force and of the Trials Working Group. The number of registered attendees for the event was 52 for in-person attendance, plus 49 for on-line attendance (the latter, being restricted to the panel discussion).

Figure 19: Panel discussion at the 6G for vertical sectors co-creation event in 5G Techritory 2024 (left), and simultaneous broadcast via the You Tube channel of the SNS-JU.

The panel discussion was broadcasted live via the SNS-JU YouTube Channel from where the recording can be watched too. At a later stage, it will also be made available as an SNS ICE podcast. Finally, the various presentations give in the workshop can also be downloaded from here[46].

The workshop included one keynote speech, presentations on experimental activities for the first 6G use cases carried out by European research projects funded by the SNS-JU as well as information about international trials and pilots with the purpose of providing a global view on 6G status. A tracking tool for vertical on 6G EU funded research was also presented along with main KPIs were discussed for the first time publicly. Key trends in verticals sectors and an operator view on the evolution of 5G to 6G in the second part of this event for a real-word perspective on 6G adoption within industrial sectors. A final panel allowed to bring pieces together and allow attendees to interact with key speakers for final and more detailed insights into 6G for verticals. The detailed agenda of the event is shown in Table 9 below.

Table 9: Agenda of the 6G for vertical sectors co-creation event in 5G Techritory 2024.

Session	Presentation	Speaker
Session 1 **SNS JU 6G Trials & Pilots**	Achieving 6G Leadership: Objectives & Targets of SNS JU Program	Javier Albares (SNS Office)
	Mapping Vertical Trends in SNS JU Phase 1 projects from the VET	Claudio de Majo (Trust-IT)
	TrialsNet: from use case definition to large scale trials and first outcomes	Alessandro Trogolo (TIM)
	Recent Trials & Pilots in TARGET-X	Jannina Gauss (Fraunhoffer)
Session 2 **Market & Economic Aspects**	Operators' Enterprise Opportunity	V. Gautam (GSMA)
Session 3 **International Trials & Pilots**	XGMF overview and vertical related projects, social issues and implementation of 6G	S. Kozaki (XGMF, Mitsubishi Electric)
	AI-Native Open Radio Access Networks Empowering Vertical Applications	E. Takahashi (NEC)
	Trials & Pilots in the US	M. Dohler (Ericsson)
Session 4 **Panel discussion**	Challenges, Lessons learned and promising 6G technologies identified in Trials & Pilots	Raffaele de Peppe (TIM), J. Albares (SNS-O), A. Trogolo (TIM), J. Gauss (Fraunhoffer), V. Gautam (GSMA)

The opening keynote speech, offered by Javier Albares, Head of 5G/6G Programs at the SNS Office, focused on how by co-creating with key verticals, it is possible to build a sustainable, inclusive ecosystem that aligns 6G progress with Europe's digital sovereignty, economic growth and societal goals. Also, the message that we need to change the momentum in Europe and make it more positive, regarding future networks and solutions was passed. Then Claudio De Majo, Senior Research Analyst at Trust-IT, provided an overview of the so-called Vertical Engagement Tracker, an on-line platform aimed at mapping use cases stemming from projects funded by the SNS-JU, as well as the related vertical associations. The talk by Alessandro Trogolo, Innovation expert and Standardisation delegate at Telecom Italia Mobile (TIM), described the use cases addressed by the project in terms of developed applications and deployed infrastructures, as well as the KPIs and KVIs frameworks to be used for the validation of the trials' results. An insight of the first trial hold in October was also provided. Similarly,

[46] https://www.dropbox.com/scl/fo/k9og81h7ujf4hgjewtl7p/AGUa-imQPM4H4RoVwQ-URDI?rlkey=4f5zrn42s4w0cpwajv957tats&dl=0

Janina Gauss, WG Leader of Interfaces and Connectivity at the Fraunhofer IPT institute, reported on recent trials and pilots carried out in the TARGET-X project.

In the second session, which addressed market and economic aspects, Vivek Gautam an Analyst in Verticals and Telecom at the GSMA, presented key findings from GSMA Intelligence's latest research assessing operator's addressable enterprise tech services powered by 5G and 6G networks.

The session on international Trials & Pilots counted with three distinguished speakers from overseas companies. The first speaker was Seiji Kozaki, a Chief Expert/Standardisation Director at Mitsubishi Electric Corporation in Japan and, also, a member of the board of the XG Mobile Promotion Forum (XGMF), the peer organisation to the 6G-IA in Japan. He reported on XGMF projects and Mitsubishi Electric's efforts and examples of technological development aimed at solving societal issues and creating new value (economic impact) for the industry, as well as the associated technical requirements. The next presentation, given by Eiji Takahashi a Senior Research Architect at NEC Corporation, discussed how emerging trends like Open Radio Access Network (RAN), software utilisation, and AI are seen as solutions to adapt RAN standard functions intelligently for various applications. He introduced a RAN autonomous optimisation technology that dynamically controls 5G Open RAN according to the status of each user terminal, dramatically improving the productivity of applications such as the remote control of robots. Finally, Mischa Dohler, Vice President Emerging Technologies at Ericsson in Silicon Valley, highlighted the current landscape of trials and pilots in the U.S., with a focus on developments across academic, industry, and government sectors. He examined key initiatives aimed at advancing wireless communication technologies, including collaborative projects between the industry sector, leading research universities, and government agencies.

This type of information sparked relevant discussions during the panel (Figure 19). The co-creation event was closed by the SNS ICE Project Coordinator, Kostas Trichias, who summarised the key takeaways from the session and notably the panel discussion:

- **Enterprise needs that will remain unattended with 5G Advanced and could be fulfilled with 6G**: On this, it was agreed that several challenging use cases come from stakeholders that are used to relying on wired connections. Therefore, trying to provide similar service over wireless may be a way forward for 6G. Complementarily, some panellists mentioned that the uplink can still be considered a limitation of 5G for certain demanding UCs, such as those where a massive number of simultaneous data are needed.
- **Impact of regulatory and policy factors (e.g., data protection, EMF, city regulations) in the realisation of B5G/6G trials**: Indeed, all speakers acknowledged that regulation may get in the way of implementing innovation. From a managerial perspective, the involvement of real users in experimentation raises ethics issues, which further delay progress. Also, spectrum can be an issue for instance when in multi-/transnational T&P different licensing and spectrum regulations are in place in different regions/countries.
- **Priority areas for trials and pilots in the SNS-JU R&I Work Programme from 2025 onwards**: In the 2025 call of the SNS Work Programme, proposals for Trials and Pilots need to focus on one of the following verticals: (1) Industry/Manufacturing, including robotics; (2) Media, including gaming and broadcasting; (3) Transportation and logistics; (4) Emergency and Safety Services; and (5) Health. For later stages, T&Ps with verticals encompassing non-terrestrial networks are of interest too. Some speakers raised the point that a data tsunami is expected in the coming years and that we need to be prepared to face it. In the final phases of the SNS R&I Work Programme when technology will be more mature and closer to the market, it would be important to identify which verticals will emerge first to be able to serve them properly (e.g., viewing autonomous vehicles as mobile devices with HD cameras).
- **Stimulating the trust of enterprises in new technologies and existence of a strong business case**: Here, it was discussed that learning from the 5G experience is vital since backward integration is very important for most enterprises. It is also key to understand their needs and, to that aim, a sustained collaboration with vertical industries in the SNS R&I programmes is fundamental: verticals will only invest in 5G/6G technologies if the benefits of those investments become clear to them.

- **Optimum number of verticals to engage with in a T&P project**: Whereas the engagement with verticals was acknowledged to be important, there was no consensus on the perfect number of verticals to tackle in a project. In fact, there is a clear trade off with the number of verticals and the attention you can give them. Dealing with 4 verticals in a project, as it is often the case in Call 1 and Call 2 projects, is already challenging as they require intense engagement and not all verticals will benefit equally. However, an analysis of 25 verticals has taken place in Japan, attempting to evaluate the role that 5G/6G could play in them.

4.1.3.3 Co-creation event: National Initiatives

The SNS Joint Undertaking provides 900 Meuro of public funding, with another 900 Meuro expected contributions from the private side. Next to this European level funding, there are also several national 6G initiatives in EU Member States. In total these national 6G initiatives provide more than 2 billion Euro worth of funding. It is expected that the total European public funding of 6G R&I is around 3 billion Euro.

These European and national initiatives are organised differently and have different focus. However, all of the public R&I funding does have a common goal to ensure European leadership in 6G. It is therefore of interest to look for synergies between SNS and the national 6G initiatives and between the different SNS initiatives. One way of doing this is to look at the Work Programme of SNS and the different national initiatives if there are specific topics that are missing or where more synergy can be achieved between the Work Programmes.

Synergies between National 6G Initiatives and SNS-JU was the topic of a Techritory co-creation session organised by SNS ICE on October 31st, 2024. The programme for the co-creation session included presentations from Javier Albares, Head of Programmes at the SNS Office, Kostas Trichias, Carles Antón-Haro, Toon Norp, and representatives from national initiatives. In the follow-on discussion, speakers, representatives from the national 6G initiatives, leadership of the State Representatives Group, and other delegates discussed on what topics should get more attention in the Work Programmes and what could be done to improve synergies across European 6G R&I.

Results of the discussions at the co-creation event are discussion in SNS ICE Deliverable 2.2.

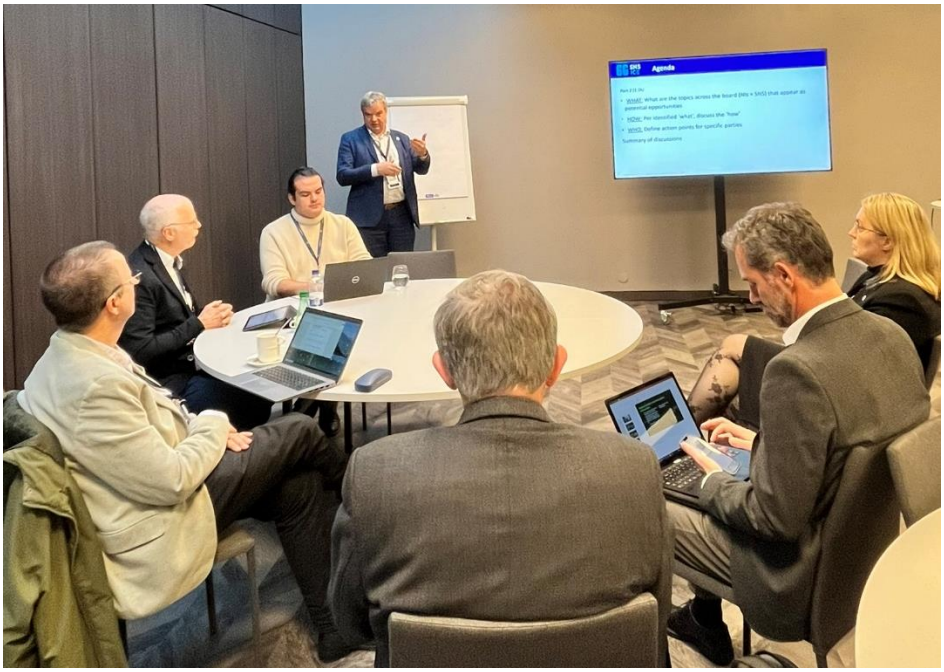

Figure 20: Group discussion at the co-creation event on synergies between National 6G Initiatives and SNS-JU.

4.1.3.4 Co-creation event: Shifting the Balance: Advancing Diversity in Telecoms R&D

In the report[47] from "The Commission to the European Parliament and the Council" on the post-evaluation of Horizon 2020, it is stressed that gender equality has progressed well under Horizon 2020, with women participating in 42% of the evaluation panels this exceeding the 40% target, whilst the share of women in scientific advisory panels is 43%. However, their participation as researchers in projects is 23% which remains well below the 50% target. Hence, strong measures are needed to support female researchers and innovators. With this aim, to create awareness and support, this co-creation session was organised. 5G Techritory is one of the strategic events in this context as it caters to a very specialised audience: the leaders and the changemakers.

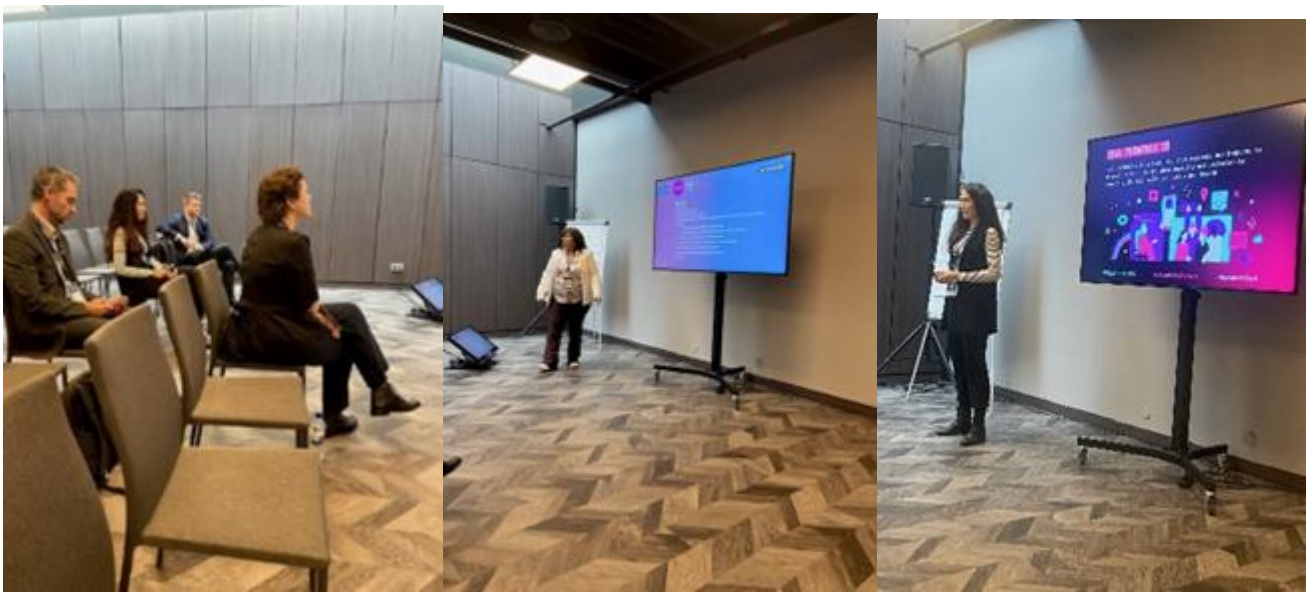

Figure 21: Several presenters participating in the co-creation event.

The session entitled "Shifting the Balance: Advancing Diversity in Telecoms R&D" was organised by Pooja Mohnani (SNS ICE project), Lina Sarma (RigaTech girls), and WiTaR (Women in Telecommunication and Research), a working group under the umbrella of the 6G-IA. The session kicked off with an introduction to WiTaR that focuses on promoting gender equality, inclusion, and empowerment in the 6G Research & Innovation (R&I) community, and of RigaTech girls which also promote equality and community. A bar camp was also included to gather industry and academia view on topics like Digital Skills, Role of diversity in Cybersecurity, Impact of diversity on 6G use cases and 6G sustainability and Ecosystem diversity. This bar camp brought diverse perspectives on the economic benefits of diverse workspaces, how it helps develop novel solutions and enhanced innovation, how social realities and inclusion promote decision making, etc. Overall, the session witnessed a good engagement and exchange with 20+ participants. The core of the session was to incorporate gender considerations in research and development. The call to action was to advocate to develop sustainability strategies in one´s workplace, that address social issues such as digital inclusion, equitable access to technology, and the creation of sustainable digital economies that benefit all.

4.1.3.5 SNS ICE showroom

The SNS ICE showroom was organised to create awareness about the European Smart Networks and Services Joint Undertaking (SNS-JU) and engage with diverse stakeholders to develop industrial leadership in Europe in 5G and 6G networks and services.

[47] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52024DC0049

The SNS ICE Showroom was available from October 30, 11:00 – October 31, 15:30. This was one place to learn about SNS-JU funded projects, the Vertical Engagement Tracker (VET) and gather insights on different use-cases, and technologies being advanced and developed within the SNS-JU. The highlights of the work performed by the SNS-JU funded projects were presented via the collection of videos.

SNS ICE project representatives also engaged and exchanged with the 70+ delegates on the work being done in SNS ICE project, the national & international collaborations, and aligned activities. Finally, a token of remembrance was distributed as a giveaway to the room attendees by the SNS ICE project in a goodie bag with SNS flyer, a power bank, a USB stick and a pocket spotlight to motivate and promote it.


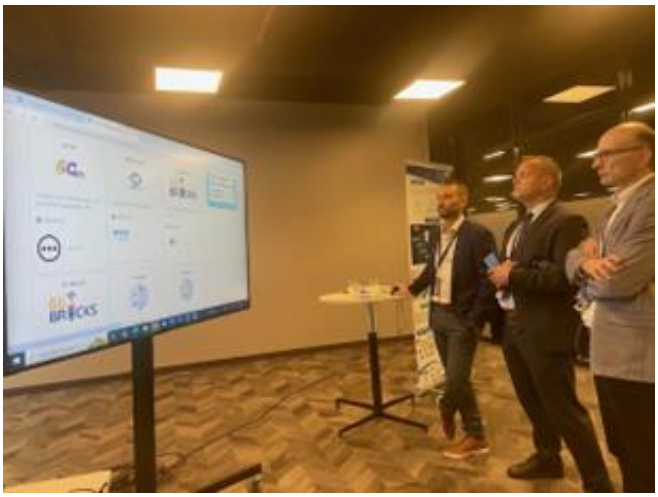

Figure 22: The SNS ICE showroom.

4.2 EuCNC & 6G Summit 2024

The EuCNC & 6G Summit combines two prominent conferences in telecommunications: the EuCNC (European Conference on Networks and Communications), supported by the European Commission, and the 6G Summit, initiated by Finland's 6G Flagship programme. Sponsored by the IEEE Communications Society (ComSoc), the European Association for Signal Processing (EURASIP), and the European Association on Antennas and Propagation (EurAAP), this event covers a wide spectrum of telecommunications topics, including 5G deployment, mobile IoT, 6G research, future communication systems, experimentation, testbeds, applications, and services. It attracts leading researchers, industries, and businesses from around the globe, drawing over 900 delegates from more than 40 countries in recent years. The conference also features an exhibition with over 50 exhibitors showcasing cutting-edge technologies, particularly those developed within EU research and innovation programmes.

This year, EuCNC was held in Antwerp (Belgium), from June 3 to June 6. The technical program included workshops and tutorials on the first day; and keynote speakers, oral and poster sessions, panel discussions and a three-day exhibit in subsequent ones.

4.2.1 Activities carried out by SNS ICE

EuCNC is of a pan-European significance since it brings together all involved stakeholders in European research activities: representatives from the SNS community, peer HEU partnerships, national initiatives, EC officers, etc. Therefore, it is an ideal forum for SNS ICE to disseminate information (strategies, plans, achievements) from SNS-JU projects, communicate to the SNS-JU community the latest trends and visions from other regions or even national initiatives and, ultimately, enable the coordination and consensus building and promote collaboration between the stakeholders. The latter also includes establishing dialogues between the SNS programme

community and Peer Partnerships as well as Associations. From all the above, it becomes apparent that EUCNC turns out to be very complementary with 5G Techritory.

To achieve those goals, **SNS ICE has engaged in a very large number of activities** in EuCNC 2024. This includes the organisation of three dedicated workshops and two convened sessions to foster collaboration and synergies with other stakeholder groups (e.g., national initiatives, vertical sectors, standardisation bodies), the participation in one panel discussion, or the publication of three articles to convey project findings on 6G research and innovation activities carried out in Europe and beyond, technology trends, definition of 6G use cases, and describing other global strategies. Table 10 below summarizes the activities carried out by SNS ICE at EuCNC24 which are described in detail in subsequent sections.

Table 10: Overview of activities organised by SNS ICE at EUCNC 2024.

Date / time	Type of activity	Title of the session	Speakers
3 June 2024, 14:00-17:30, Room Gorilla	Workshop	Trials, Pilots and Demos for Selected Verticals: The Experimental Way Forward towards 6G	Mir Ghoraishi, Gigasys, M. Dieudonne, Keysight, V. Frascolla, Intel, A. Díaz, U. Málaga, R. de Peppe, TIM, M. Vircik, Matzuko, K. Trichias, 6G-IA
3 June 2024, 9:00-12:30, Room Nightingale	Workshop	EU Collaborative Research & Innovation Focal Points in the SNS-JU	P. Fournogerakis, DG-CNCT; M. Fallgren, Ericsson; K. Trichias, 6G-IA; M. Dieudonne, Keysight; I. Tomkos, U. Patras; O. Bulakci, Nokia; D. Artuñedo, Telefonica
3 June 2024, 9:00-12:30/14:00-17:30, Room Darwin Hall	Workshop	Hexa-X-II Workshop	Speakers from Nokia, Ericsson, WINGS, TNO, CyberEthics Lab, and various universities.
3 June 2024, 14:00-17:30, Room Nightingale	Panel	Panel discussion in the workshop "Research on 6G: what's in EU member States?	A. Pouttu (FI), M. Payaró (Spain), G. Bonnechere (F), N. Blefari, A. Capone (I), T.Norp, Wijngaard (NL), P. Kelly, D. Kilper (IE), S. Stanczak (D)
4 June 2024, 16:00-17:30, Room Gorilla Room 1	Convened session	How to accelerate 6G research through global standards	D. Boswarthick, S. Almagia, ETSI, M. Gonzalez-Sancho, DG CONNECT, P. Fournogerakis, SNS, T. Norp, TNO, R. Trivisonno, Huawei, A. Mourad, Interdigital, P. Sehier, Nokia
5 June 2024, 11:00-13:00, Room Gorilla Room 1	Convened Session	European Vision on 6G Use Cases	P. Fournogerakis, SNS, D. Bourse, Nokia, C. Willcock, 6G-IA, T. Norp, TNO, M. Uusitalo, Nokia, H. Schotten, U. Kaiserslautern
Several Sessions	Papers	6G Research & Innovation Activities in Europe: An Overview of EU & Nationally funded Programmes	K. Trichias, A. Kaloxylos and C. Willcock, 6G-IA, C. Anton-Haro, CTTC, C. de Majo, TRUST-IT, J. Beriere, T. Norp, P. Sachdeva, TNO, P. Mohnani, EURESCOM

		6G Global Landscape: A Comparative Analysis of 6G Targets and Technological Trends 6G Smart Networks and Services: Global Strategies, Main Work Directions & Future Outlook	

In addition to all those activities, SNS ICE run a **booth in the EuCNC exhibit area** for the whole duration of the conference (see Figure 23). Booth materials included project flyers, rollups, printed copies of 6G-IA/SNS ICE whitepapers and other strategic documents, information on the Vertical Engagement Tracker on-line tool, among others.

Figure 23: The SNS ICE team at EuCNC 2024 in Antwerp, BE

Figure 24: Screenshot of the summary video on SNS ICE activities at EuCNC24.

To reinforce and further strengthen the dissemination of the activities carried out by SNS ICE after the closure of the conference, a summary video was produced, which is available via the SNS ICE YouTube channel[48]. Further

[48] https://youtu.be/P9NX5ldVmMQ?list=PLdoUExp7oG-5eGlCp8jqlpjlMBzrc18Hr

details on booth activities and other multimedia materials produced on the occasion of EuCNC and other events can be found in deliverable D4.2.

4.2.1.1 *Trials, Pilots and Demos for Selected Verticals: The Experimental Way Forward towards 6G*

The realisation of large-scale trials, pilots and demonstrations with a strong involvement of verticals from the early stages of 6G research is key. This makes it possible to (i) assess network performance in realistic conditions; (ii) gain a better understanding of customer needs; and (iii) elaborate more accurate business models. Europe has a long record track in conducting large-scale trials and pilots for B5G and 6G technologies. Under the umbrella of the 5G-PPP and, in recent years, of the SNS-JU. This workshop[49] was led by SNS ICE and counted with the support of selected SNS projects from Stream B, C and D, namely, FIDAL, 6G-XR, PREDICT-6G, 6G-SANDBOX. Their representatives shared their views, achievements, and lessons learnt from the realisation of early trials, pilots and demonstrations in their respective projects which cover key verticals for the EU economy such as industrial manufacturing, media and entertainment, gaming, public protection and disaster relief, or smart cities.

Table 11: Agenda of the SNS-JU Trials, Pilots, and Demos for 6G WS @EUCNC 2024.

Time	Agenda item
14:00-14:05	**Welcome and introduction to the workshop.**
14:05-14:30	**Keynote Speech: "International 6G Technology Trials: Status, Expectations, and Outlook"**
14:30-15:30	**Technical Session #1: Initial Results of 6G SNS Trials, Pilots and Demos** - "Selected use case experimentation with 6G-SANDBOX: initial results," M. Dieudonne (Keysight), P. Merino (U. Malaga), H. G. Koumaras (NCSR Demokritos), B. Riemer (Fraunhofer Fokus) - "PREDICT-6G: The synergy between Digital Twins, Time-Sensitive Networking, and Wi-Fi for Industry 4.0", V. Frascolla (Intel) - "Demonstration of slicing for PPDR communications", A. Díaz, M. Morero, J. Jiménez (University of Málaga), S. Delmas (Airbus)
15:30-16:00	**Coffee break**
16:00-16:40	**Technical Session #2: Technology Enablers and Futuristic Use Cases** - "Trend analysis of new verticals towards 6G", R. de Peppe (TIM) - "6G-XR: Technology enablers for a realistic holographic presence", M. Vircik (Matzuko)
16:40-17:25	**Panel discussion: "Challenges, lesson learnt and promising 6G technologies identified in SNS Trials and Pilots"** Panelists: A. Díaz (U. Malaga), M. Dieudonne (Keysight), K. Trichias (6G-IA), V. Frascolla (Intel), Mir. Ghoirashi (Gigasys Solutions), Didier Bourse (Nokia).
17:25-17:30	**Wrap up and conclusions from the workshop**

The agenda, shown in Table 11, included one keynote speech by Mir Ghoirashi from Gigasys Solutions who is also a chair of the International Trials Stream of the 6G-IA Trials WG. His talk provided details around recent 6G Trials and Pilots conducted in Japan by NEC; and in China by a consortium including Shanghai Nokia Bell, Ericsson, China Mobile, China Telecom, China Unicom, Huawei, ZTE, Vivo and Inspur. This was followed by two technical sessions. The first one reported on initial results from selected European Trials, Pilots and demos carried out by SNS projects. The second one focused, on one hand, on the identification of futuristic use cases as per the trend analysis report elaborated by Raffaele de Peppe in the course of the execution of the SNS ICE project; and, on the other, on technology enablers for AR/VR/XR identified in Stream C project 6G-XR. All presentations were backed by technical papers which were included in the conference proceedings.

The workshop also counted with a panel session where all presenters participated. Discussions revolved around topics such as the features of 5G/B5G technologies (e.g., low-latency, virtualisation) that had proved to be

[49] https://www.eucnc.eu/programme/workshops/workshop-9/

particularly useful in their trial and pilots; the requirements (e.g., latency, throughput, coverage) in their respective verticals that were more difficult to meet by 6G networks; the main lessons, technical and non-technical, learnt from running pre-commercial trials and pilots; the impact of regulatory or policy factors, or replicability aspects of those trials.

Very importantly, panellists were also asked to provide feedback/suggestions that could be used for the definition of SNS R&I Work Programmes. This triggered a very lively discussion on the role to be played by current Stream C (platform) projects in Stream D projects in future calls, the challenges that the integration of Stream C platforms (or part of them) into Stream D projects entail, the extent to which additional platform developments should be allowed in future Stream D projects, or the optimal number of verticals to be addressed in those projects. The various points of view expressed during the panel discussion were properly captured and, at a later stage, fed into the definition of the SNS R&I Work Programme 2025, that was then under preparation.

Figure 25: SNS-JU Trials, Pilots, and Demos for 6G WS @EUCNC 2024.

4.2.1.2 EU Collaborative Research & Innovation Focal Points in the SNS-JU

The SNS-JU is about enabling collaborative research and creating a positive inter-working environment, where vision, approaches and outcomes are discussed resulting in broadly accepted insights. Instrumental SNS-JU entities are in place to enable and encourage such work environment. The Steering Board (SB) and Technology Board (TB) act as the main governance bodies for coordination of activities between projects and drive project alignment on roadmap and technological levels. The SNS-JU Project Working Groups (SNS-JU WGs) are coordinating bodies of activities relating to specific technical scopes of interest.

During EuCNC 2024, SNS ICE facilitated the organisation of a workshop[50] focusing on the way that the SNS-JU projects collaborate for their research and the collaborative bodies in place. In this workshop, the approach towards EU collaborative R&I work was presented from the SNS-JU office, while the overview of the SNS projects' vision, roadmap, technological enablers, and domain coverage was also discussed from the SB and TB perspective. Moreover, a deep dive into the technical challenges and scope of the SNS-JU Project WGs took place by SNS experts, resulting in a panel discussion on the current technical focus of the SNS-JU and its way forward.

Figure 26: SNS-JU Collaborative Research WS @EUCNC 2024.

Figure 26 provides a couple of snapshots from this workshop, where working group leaders and projects experts shared their views on the approach to project collaboration and on potential ways to improve it.

4.2.1.3 Hexa-X-II Workshop

The European Flagship project Hexa-X-II[51], funded under the SNS-JU, aims to create strong foundation on 6G values and requirements seeing how the 6G design could strive for economic, social, and environmental sustainability in all its facets. The project is also conducting research on architectural enablers, radio evolution, 6G devices & infrastructure, and smart network management. As such, the Hexa-X-II project, organised a Workshop[52] in the context of EUCNC 2024 addressing Physical Layer and Fundamentals, Wireless, Optical and Satellite Networks, Network Softwarisation, IoT, Use Cases and 6G Visions and Sustainability, by providing an overview on the 6G research from the major European players. The workshop provided an opportunity to solidify

[50] https://www.eucnc.eu/programme/workshops/workshop-5/
[51] https://hexa-x-ii.eu/
[52] https://www.eucnc.eu/2024/www.eucnc.eu/programme/workshops/workshop-3/index.html

Hexa-X-II's position as a leading 6G project, showcasing the work done with presentations, as well as provide an opportunity to connect and align with the 6G research performed elsewhere.

The SNS ICE project directly contributed to this workshop, via a presentation from its coordinator (see Figure 27), focusing on "Global & EU landscape of Collaborative 6G R&I activities". During this presentation, the SNS ICE approach to collecting information from global, European and Vertical stakeholders was presented, along with the insights gathered from the latest work of SNS ICE WP1 and WP2, hence painting the picture of the current R&I landscape and how it compares to the SNS-JU projects' activities. The presentation was very well received, and all the WS participants appreciated the high-level overview of the global and EU research landscapes and how they match with the SNS-JU activities.

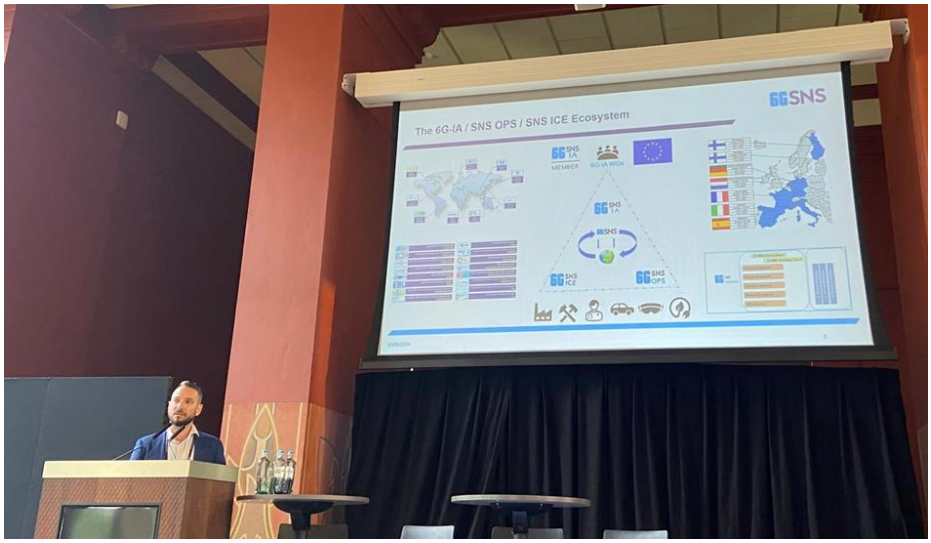

Figure 27: SNS ICE presentation @Hexa-X-II WS at EuCNC 2024

4.2.1.4 National Initiatives Panel

A workshop[53] 'Research on 6G: what's in EU Member States?' on national initiatives was organised by two representatives of national initiatives, Stanislav Stanczak from the 6G Platform Germany and Umberto Spagnolini from the Italian Restart initiative. SNS ICE helped with this workshop by providing contact details of the speakers from the various national initiatives. The workshop provided presentations from a number of national initiatives about the structure and activities of these national initiatives. and a number of presentations on from industry leaders on their vision. There was also a panel discussion discussing ways to improve collaboration across and identifying topics of interest for collaboration. Toon Norp represented SNS ICE in the panel. Organising workshops was identified as a suitable way to collaborate.

[53] https://www.eucnc.eu/2024/www.eucnc.eu/programme/workshops/workshop-1/index.html

Figure 28: National Initiatives panel at EuCNC 2024

4.2.1.5 How to accelerate 6G research through global standards

SNS ICE co-organised this convened session[54] with ETSI in order to bring the SNS-JU researchers in contact with standardisation experts and bridge the gap between research and standardisation in the hopes of accelerating the technology transfer from research to standards and then to market. As the success of the Smart Networks and Services (SNS) Joint Undertaking relies not only on the technical results of the projects but also on a strong valorisation of EU research in standardisation bodies, it is important for EU stakeholders to prepare for this crucial phase. Also new developments are happening in industry, like disaggregation and softwarisation of networks, the raising importance of cloud technology that may eventually have an influence on the standardisation process. Similarly, new topics like Artificial Intelligence are emerging as being highly prominent in 6G. Against this background, the purpose of this convened session was to raise awareness of the standardisation directions, focus, priorities and challenges that the research community should take into account with the objective of preparing the widest possible EU industrial base to be in prime position for the upcoming 6G standardisation, and also to prepare for the next SNS phases which will have a strong standardisation component.

The session was opened by the 6G-IA Chairman of the Board and SNS ICE member along with the Directors of Norme Européenne de Télécommunication (NET) in ETSI, who highlighted the importance of standardisation for EU researchers, followed by experts who are both researchers and standardisation experts highlighting the current challenges. An overview of the current status of standardisation efforts within the SNS-JU was provided by the 6G-IA Pre-Standardisation WG chairman and an overview of the operation of ETSI was provided by the Director of Software Standards within ETSI. Finally, several successful examples of bringing research into standards were provided by experts, followed by an interesting panel discussion on how can the SNS-JU output towards standards be improved and how to maximize the impact of EU R&I projects.

4.2.1.6 European Vision on 6G Use Cases

One of the most significant accomplishments of the SNS ICE project during 2024, was the leadership, organisation and facilitation of the effort to align the European view on the 6G Use Cases to be prioritised by 3GPP, and the respective presentation at the 3GPP SA1 workshop in Rotterdam (NL) in May 2024 (see Section 2.2.2 and

[54] https://www.eucnc.eu/2024/www.eucnc.eu/programme/special-sessions/convened-session-2/index.html

deliverable D2.2 for more details). Based on this effort, it was considered of interest from the perspective of the EUCNC audience and wider research community in Europe, to explain this European wide consensus on 6G use cases and how did that come about, what inputs/ideas were received from national initiatives and SNS projects, whether there is consensus also between the European R&I vision on use cases and other regions, and similar questions.

As such, SNS ICE organised a convened session[55] during EuCNC 2024 entitled "European vision on 6G use-cases". This session at EUCNC allowed SNS ICE partners to share for the first time the results of the May 2024 3GPP SA1 workshop (as the workshop itself is by invitation only), and to discuss in a panel with key European stakeholders on the next steps regarding standardisation and European priorities from R&I projects.

The event was led by the SNS ICE WP2 leader and comprised presentations from key stakeholders including EU National Initiatives representatives, standardisation experts and industry leaders, discussing their view on the use cases that should be prioritised for 6G and on how to get from R&I activities to actual real-world deployments. During the same event, a panel moderated by the SNS ICE coordinator (see Figure 29), dove deeper into the technicalities of contributing to standardisation from EU R&I projects, and expanded on potential ways for further collaboration and alignment among European stakeholders.

Figure 29: SNS ICE convened Session @ EUCNC 2024 on European 6G Use Cases

4.2.1.7 Highlights on papers contributed by SNS ICE

Besides the organisation of several events and the facilitation of multiple more at EuCNC 2024, SNS ICE partners also grabbed the opportunity to further promote the project's work towards the EuCNC audience, via the publication of some critical results insights, obtained during the first period of the project's work from WP1 and WP2. Three papers were authored by SNS ICE partners (see Figure 30), each focusing on the main insights gained during the project work in these two Work Packages. After going through the standard EuCNC peer review process they were accepted for presentation at the conference. More specifically these publications were:

- **6G Global Landscape: A Comparative Analysis of 6G Targets and Technological Trends** [1]: This publication presented the analysis of the global 6G trends in terms of prioritised 6G use cases, KPIs and

[55] https://www.eucnc.eu/2024/www.eucnc.eu/programme/special-sessions/convened-session-3/index.html

technological enablers, based on the research performed by WP1 and presented in this deliverable in Section 4.2.1.7.

- **6G Smart Networks and Services: Global Strategies, Main Work Directions & Future Outlook** [1][12] : This publication focused on the international R&I landscape that SNS ICE is interacting with, discussing the interaction with other global regions and how they affect the generation of the SNS-JU Work Programmes.
- **6G Research & Innovation Activities in Europe: An Overview of EU & Nationally funded Programmes** [13]: This publication presented the outcomes of the extensive research and interviews that took place with several EU National Initiatives in the context of WP2, focusing on their respective priorities and how they match with the SNS-JU research priorities.

All above publications, were presented during EuCNC 2024 by SNS ICE partners, spreading valuable information regarding the position of SNS-JU compared to the world and further promoting the work taking place by the SNS-JU projects. All publications are available via the IEEE xplore and via the SNS ICE website[56].

Figure 30: SNS ICE peer reviewed publications presented at EuCNC 2024

4.3 Other International events

In addition to the SNS ICE activities in 5G Techritory 2024 and EuCNC 2024 reported in previous sections, SNS ICE partners have been very active in multiple international events during the second year of the project (2024). In fact, since its beginning in January 2023, the SNS ICE project has taken over virtually all activities with regards to international event planning and attendance. A detailed list of all the events that SNS ICE partners organised, participated in and/or facilitated during 2024, is provided in the SNS ICE Deliverable D4.2. Still, some additional details are provided in this section regarding key events with international impact (and participation of stakeholders from other regions of the world), and the contribution of SNS ICE to each respective event.

[56] https://smart-networks.europa.eu/csa-s/#SNS-ICE

- B5G Promotion Consortium International Conference (Tokyo, Japan; 1-2 February 2024): The Japanese Ministry of Internal Affairs and Commerce (MIC) and Beyond 5G Promotion Consortium co-hosted an annual conference for international collaboration to promote B5G. Colin Willcock from SNS ICE presented a keynote presentation on "The European path towards 6G Networks" which included some background and latest status on the SNS-JU program together with some insight into the key technical areas identified in the European 6G strategy. The presentation also included some proposals for possible areas for future collaboration. The event attracted several hundred people, mainly from Japan but also with some international participants from across the globe. The event provided a unique opportunity to talk with private and public representative of the Japanese 6G research activities and discuss further collaboration.
- Mobile World Congress 2024 (Barcelona, Spain; 26-29 February 2024): MWC Barcelona is *the* event in the world of connectivity which gathers tens of thousands of senior leaders from top global companies, international governments and high-tech businesses converge to connect and create the future of mobile communications. Taking advantage of CTTC's booth at the event, SNS ICE showcased selected project results. Dissemination materials included a roll-up with project highlights a and a summary of results and achievements from its first year. This allowed to spread the word of SNS ICE and the SNS-JU to the many visitors of the booth, this including device manufacturers, network equipment providers, representatives of wireless carriers, national and regional politicians and officers, and the press, among others. Booth visitors also included the Executive Director, the Head of 5G/6G programmes, and one Scientific Officer of the SNS Joint Undertaking. In those days, CTTC also generated news and tweets on CTTC's social media on the participation of SNS ICE at the event, and re-tweeted selected SNS ICE posts.

Figure 31: Presentation at WWRF Huddle 2024, Berlin.

- WWRF Huddle 2024 (Berlin, Germany; 17-18 April 2024): The WWRF Huddle is the yearly flagship event of the Wireless World Research Forum, bringing together policy makers, connectivity and service providers, researchers and other key stakeholders. This year's WWRF Huddle was organised at Fraunhofer Fokus in Berlin. The WWRF Huddle 2024 was focused on 6G as the 6G vision is taking shape. The conference addressed key themes such as 'goals and targets for 6G', 'non-terrestrial networks', 'emerging technologies', 'sustainability through 6G', 'security and privacy', and 'evolving business models'. The SNS ICE project was represented by Bernard Barani, who gave a presentation on '6G R&I in

the European SNS Initiative', and Toon Norp, who participated in a panel session on 'Balancing realism and ambition – Goals and targets for 6G'.

- IEEE Wireless Communications and Networking Conference 2024 (Dubai, UAE; 21-24 April 2024): IEEE WCNC is the world premier wireless event that brings together industry professionals, academics, and individuals from government agencies and other institutions to exchange information and ideas on wireless advancement communications and networking technology. This year Carles Antón-Haro was invited to give a keynote speech entitled 'EU-US roadmap for collaboration in the definition of Beyond 5G and 6G communication systems' in the Network Management for 6G Communication Systems (NetMan6G) workshop. The talk was based on the ATIS/6G-IA joint position paper "EU-US Beyond 5G/6G Roadmap" in which several SNS ICE members participated. It gathers strategic reflections and recommendations for 6G networks and services, capturing the views and priorities from Next G Alliance in the US and the SNS-JU in Europe. The ultimate goal of the position paper is to scale up the existing R&D cooperation on 6G between the U.S. and EU funding agencies, align interests in global regulatory and standardisation bodies, and cooperate in technology trials and pilots to foster market adoption. The talk was aimed to disseminate the aforementioned reflections and recommendations and bring them to the attention of a selected scientific audience.
- 5G FORUM (Sevilla, Spain; 2-7 May 2024): This is the leading event about 5G technology held in Spain. Every year, the 5G FORUM puts on stage the latest advances of 5G technology, and acts as a meeting point for the exchange of knowledge on the practical applications of this technology. Keynote speakers include high-ranked officers from the European Commission and Spanish Ministries and agencies. C-level representatives from leading companies (mobile network operators, equipment vendors, system integrators), and well-known researchers and faculties from prestigious universities and research centers. In this year's edition, the sixth in the series since 2018, Carles Antón-Haro gave an invited speech entitled 'Setting up an EU-US roadmap for collaboration in the definition of Beyond 5G and 6G communication systems' which, again, is based on the aforementioned ATIS/6G-IA joint position paper "EU-US Beyond 5G/6G Roadmap". Hence, this is also a dissemination activity although, in this case, the interest of the audience is closer to operational and exploitation/monetisation activities around wireless networks than to scientific and network design aspects.
- IEEE International Conference Machine Learning for Communication and Networking (Stockholm, Sweden; 5-8 May 2024): This conference brings together researchers from the disciplines of Machine Learning (ML) and Communication and Networking. It is aimed at promoting fundamental and applied research of ML for designing and analyzing communication systems and networks, for developing communication protocols to support ML services, as well as for advancing distributed ML over communication networks. In this privileged forum, Carles Antón-Haro organised the industry panel discussion entitled 'AI-native 6G radio interfaces: what can hardware acceleration really bring about?' The panellists included senior experts and principal engineers from first-tier network equipment vendors (Ericsson, Nokia), top officers from thriving SMEs working in the field (DeepSig), and renowned researchers from academia (Imperial College). Discussions revolved around the main algorithmic bottlenecks towards the development of an AI-native 6G radio interface, the most promising technologies and strategies to minimize/mitigate the complexity of AI/ML-based functionalities in radio access networks, or the main challenges and limiting factors of today's hardware acceleration platforms, among others. All those topics are closely related with several areas of the SNR R&I Work Programme such as STREAM-B-02: Wireless Communication Technologies and Signal Processing; or STREAM-B-05: Microelectronic – Front-End Module (FEM).
- 6G and Future Networks conference (London, UK; 24-25 June 2024): The 6G and Future Networks attracted several hundred people and was split into a number of streams covering aspects of 5G and 6G. The audience was mainly from the UK with strong representation from UK industry but also a strong presence of people from the defence eco-system. Colin Willcock from SNS ICE gave a keynote speech on

"Update on European 6G Research Program SNS-JU and what it means for the Telecom industry". The key goal was to increase awareness and hopefully participation of UK organisations in the SNS-JU. Overall the participation of UK organisations has greatly reduced under the effects of BREXIT and now that the situation with UK participation in horizon Europe is clarified it is important for SNS ICE to invest effort to reconnect with the UK research ecosystem and make them aware of possibilities.

- Berlin 6G Conference 2024 (Berlin, Germany; 1-4 July 2024): This year the Berlin 6G Conference attracted nearly 900 people. The majority of the participants were from the German research eco-system both academic and industrial, but there was also a significant number of European and international participants. The SNS ICE project was well represented at the 6G conference. The 6G Platform Germany organizes this yearly 6G conference to bring together people involved in the German National 6G initiative. It was a unique opportunity to link the German National 6G research program with the European level SNS-JU. Colin Willcock, in his role of chairman of 6G-IA presented achievements and plans from the SNS-JU. Toon Norp presented the main takeaways from the 3GPP SA1 workshop in Rotterdam, with specific attention for the European consolidated use case input that the SNS ICE project has helped establish.

Figure 32: Presentation from SNS ICE at the Berlin 6G Conference 2024.

- Global 5G Event 2024 (New Delhi, India; 29-30 August 2024): The Global 5G Event attracted around 150 people physically on-site and many more online. The participation was mainly Indian academics and industry with a good number of international participants. Colin Willcock from SNS ICE presented a keynote on "Status of 6G Research in Europe" which gave the background and status of the SNS-JU program and focused on research in the key areas of AI and cloud. This event provided the opportunity to better understand the global status of 6G research and specifically link to the burgeoning Indian 6G research activities.

- 6G world: 6G symposium Crucial conversations (Washington D.C, USA; 23rd September 2024): Alexandros Kaloxylos participated at the event where he made a clear case for sustainability and why measurable indicators are needed. He explained that in Europe, based on the work of the Hexa-X and Hexa-X-II projects as a starting point, a framework on Key Value Indicators (KVIs) is under development and promoted the work of related SNS-JU projects. This framework when fully developed will be a key impact of the SNS-JU in the global activities for the 6G Networks.

Alexandros Kaloxylos also participated in a side meeting with experts from around the world, discussing the priorities and challenges on the path to 6G networks. He also discussed with US counterpart experts about the possibilities for further collaboration between EU and US under the umbrella of the Trade and Technology Commerce (TTC).

- 6G Forum: The next step will 6G deliver? (on-line; 1 October 2024): Alexandros Kaloxylos participated in a panel discussion, including well-known experts from around the world, regarding the challenges of making 6G a reality and explore the essential question: 'Why do we actually need 6G?'. He presented the latest status of the SNS-JU activities and identified the key priorities and the main challenges. He discussed how these activities are in full support of the EC policies as well the European private side priorities. He has also elaborated on the identified key enablers for 6G networks (e.g., AI/ML, deterministic networking, flexible architectures, ISAC, integration of terrestrial and satellite networks, etc.). He has also provided information on how the SNS projects are designed to address sustainability and provide solutions with a strong potential for monetisation.

- EU-Taiwan Joint 6G SNS Workshop (Taipei, Taiwan; 6 October 2024): The EU- Taiwan joint 6G SNS workshop had presentations from the EU side on the current status and plans in regards to the SNS-JU and European 6G research. From the Taiwanese side there were presentations and demonstrations from successful SNS-JU projects which Taiwan organisations have taken part in. About a hundred people attended the event physically with many more participating remotely. The audience was a mixture of academics, industry and government representative. SNS ICE was instrumental in organizing this event together with ITRI and provided one of the presentations from the EU side. The excellent results showing the strength of combining the strong points from both regions were followed up with the clear wish from both sides to expand such cooperation. In addition to this event, visits to a number of interested Taiwanese companies and the ITRI research centre were organized

Figure 33: Presentation from SNS ICE at the EU-Taiwan Joint 6G SNS Workshop.

- Global 6G Symposium' / India Mobile Congress (IMC) 2024 (New Delhi, India; 16-17 October 2024): The 8th Edition of India Mobile Congress (IMC) 2024, jointly organised by the Department of Telecommunications (DoT) and the Cellular Operators Association of India (COAI), had the largest ever participation with over 175,000 participants attending the 4-day forum. The event was inaugurated by Honorable Prime Minister Narendra Modi, who called for global standards in ethical AI and data privacy and highlighted India's tremendous opportunity to advance 6G technology for the world during his inaugural speech. The global 6G symposium was an integral part of the event attracting several hundred

people was organised by the Indian Bharat 6G Alliance and was opened by the Indian minster for Telecoms. Colin Willcock from SNS ICE took part in a panel session on International research collaboration for 6G. This included a presentation on what the SNS-JU via SNS ICE has done in the field of international collaboration and also highlighted future collaboration opportunities from the European point of view. The presentation was well received and led to significant discussion with Indian participants and representatives about possible future EU – India collaboration activities. It also gave the chance to talk extensively to UK representatives from academia and government about improved alignment between UK and EU 6G research.

Figure 34: Panel discussion at the Global 6G Symposium with SNS ICE participation.

- 2024 Brooklyn 6G Summit (Brooklyn, NY, USA; 23-25 October 2024): The Brooklyn 6G summit is an invitation only event with about 350 participants. The audience are high-level industry representatives from around the world plus key academics. It is an excellent event to understand the actual view of the telecoms industry as well as seeing the latest cutting-edge academic research. For SNS ICE this event gave the possibility to gain impact and awareness of the SNS-JU across a broad set of international decision makers. It also gave a unique opportunity to interact with key industrial, academic and government representatives in the US eco-system with a view to future collaboration. SNS.ICE was well represented with Colin Willcock taking part in the panel "6G Gaps and Priorities" which offered the chance to talk about 6G research in Europe and the initial results from the SNS-JU. In addition, Alexandros Kaloxylos from SNS ICE concentrated on EU – US collaboration with offline meetings and discussions across the academic, industrial and governmental domains.
- ETSI: Software and Standards for Smart Networks & Services (Sofia-Antipolis, France; 12-14 November 2024): Alexandros Kaloxylos attended the Software and Standards for Smart Networks and Services Conference & Hackfests conference[57] organised by ETSI. Alexandros Kaloxylos was a member of the Programme Committee. He presented in session 5 and also took participated in the related panel[58]. During the days of the meeting, he had also the opportunity to collaborate with the Executive Director of the SNS-JU Ms. E. Fitori, and the deputy Head of Programmes, Mr. P. Fournogerakis for the organisational topics of the SNS-JU and the presentation of SNS R&I WP to the SRG.

[57] https://www.etsi.org/events/2407-etsi-sns4sns-event
[58] https://www.etsi.org/events/2407-etsi-sns4sns-event#pane-2/

- Global 6G Development Conference - IMT-2030 (Shanghai, China; 13-14 November 2024): The global 6G Development Conference took place on the 13th and 14th of November in Shanghai. It attracted around 400 participants with strong participation from Chinese industry and government. There were also several international participants from Europe and Asia. Colin Willcock representing SNS ICE Presented a keynote on European-level 6G research. This gave a snapshot of the current status of the SNS-JU at a high-level, and highlighted the key technological areas which are being addressed.

Figure 35: SNS ICE presentation at the Global 6G Development Conference 2024.

- UKTIN International & Horizon Engagement Conference (London, December): This event provided delegates with the opportunity to hear from senior government officials on the strategic importance of international innovation programmes, from industry and association bodies on the opportunities, plans and next steps to engaging. Alexandros Kaloxylos provided information about the SNS orientations for future calls and the identified priorities on the road to 6G. He also participated in a panel with European consortia leaders to discuss tools (e.g., SNS brokerage tool) and opportunities for UK stakeholders to engage in SNS activities.

4.4 Key insights based on SNS ICE analysis

In 2024, SNS ICE has engaged in a **very large number of activities in international workshops and events**. This has been instrumental to successfully disseminate the achievements of the SNS-JU project portfolio, strengthen global dialogues, increase the footprint of European players in the international 6G arena (i.e. beyond the R&D community) and, also, effectively monitor and analyse EU, national and global trends. The portfolio of events targeted by SNS ICE partners has been very **diverse and synergistic**, including a few large events with a massive project involvement, like 5G Techritory or EuCNC (Section 4.1 and 4.2, respectively); and a large collection of international events with a more focused participation (Section 4.3).

In those events, SNS ICE was **able to mobilize key stakeholders** from the SNS arena, including C-level executives from major industrial players based both in the EU and overseas (e.g., Ericsson, Nokia, NEC Mitsubishi, Vodafone, Telefonica), industrial associations effectively driving the evolution towards 6G networks (e.g., XGMF, IMT 20230 PG, Next G Alliance, 6G-IA), coordinators and technical managers of flagship projects in the SNS portfolio (Hexa-X-II, TargetX, TrialsNet), vertical companies and associations (Bosch, 5G AICIA, 5G AA to name a few), renowned researchers from research centres and universities, and high ranked officers from EC and national agencies. This

provides a very **solid ground for the identification of key insights** stemming from those discussions which are outlined in subsequent paragraphs. Besides, running booths in major events (e.g., Technritory, EUCNC and MWC) SNS ICE assisted to **effectively convey SNS messages** to the many visitors who belonged to complementary audiences.

The panel discussion entitled "Why 6G – The European Priorities" highlighted the enthusiasm surrounding 6G services while stressing the need to **align development with practical, real-world requirements**. Vertical sectors, in particular, were identified as needing early consideration to ensure their needs are met effectively. An important opportunity identified for 6G was the potential to **deliver wireless services comparable in quality to wired connections**, a capability not yet achieved by 5G Advanced. In line with that, in the final phases of the SNS R&I Work Programme it will be of utmost importance to identify **which verticals will emerge first** to serve them properly, as discussed in the co-creation event on 6G for vertical sectors at 5G Techritory. Another key insight from this co-creation event was getting to know about **XGMFs projects** and Mitsubishi Electric's efforts in trials and pilots aimed at **solving societal issues** and creating economic impact for the industry. And how emerging trends like Open Radio Access Network (RAN), software utilisation, and AI are being explored in NEC's experimental deployments; and key initiatives in the US aimed at advancing wireless communication technologies towards 6G, including collaborative projects between the industry sector, leading research universities, and government agencies. In those projects, however, **the involvement of vertical companies in US trials seems to be much lower than in other world regions**, this including the SNS-JU project portfolio in Europe.

The EuCNC workshop on 'Trials, Pilots and Demos for Selected Verticals: The Experimental Way Forward towards 6G' was very helpful to get **first-hand insights from on-going SNS projects** about the roles of ongoing Stream C platform projects in future Stream D projects. Challenges related to Stream C platform integration and to what extent further developments should be allowed, were explored in detail. Key findings were incorporated into the definition of the SNS R&I Work Programme for 2025. Hence, it would be advisable to adopt a similar strategy in upcoming editions of EuCNC.

Events like EUCNC and Techritory also highlighted the diversity of organisational approaches in European and national initiatives, underscoring shared goals to secure European leadership in 6G. Therefore, it is of utmost importance to **look for synergies between SNS and those national 6G initiatives** One possibility, that was agreed upon, was to scout the respective Work Programmes for gaps to be addressed, or where more synergy could be achieved.

The leadership, organisation and **facilitation by SNS ICE of the effort to align the European view on the 6G Use Cases to be prioritised by 3GPP**, and the respective presentation at the 3GPP SA1 workshop in May 2024 shed some light on the EU priorities and vision on this area. Shortly after, in an SNS ICE convened session at EUCNC'24, this very significant accomplishment of SNS ICE was conveyed and brought to the attention of the wider research community in Europe. Along with that, further discussions during the workshop "How to Accelerate 6G Research through Global Standards" highlighted successful examples of SNS-JU projects research being translated into standards and **strategies to maximize SNS-JU's impact in global standardisation efforts**.

The more focused **international events** where SNS ICE participated were **vital to seek for an alignment of worldwide priorities** towards the definition of a unified 6G standard. Key discussions at events like the 6G World summit included side meetings aimed at **exploring collaboration opportunities between the EU and the US** under the Trade and Technology Commerce framework. At the Brooklyn 6G Summit, interactions with U.S. industrial, academic, and government representatives helped lay the groundwork for future partnerships. Besides, the ATIS/6G-IA joint position paper "EU-US Beyond 5G roadmap was disseminated via talks, at the IEEE Wireless Communications and Networking Conference for a selected scientific audience and at the 5G FORUM for an audience which is closer to operational and exploitation activities.

At the B5G Promotion Consortium International Conference, SNS ICE provided an updated way on the SNS-JU program, some insights into the key technical areas identified in the European 6G strategy, and proposals for possible areas for future collaboration in front of a large audience mainly from **Japan** and other countries in the

Asia-Pacific region. Complementarily, the **EU-Taiwan** 6G SNS Workshop, jointly organised by SNS ICE and ITRI gave excellent results and underscored the critical importance of combining the strengths of both regions as well as the willingness of both regions to further pursue cooperation. Likewise, the Global 5G Event 2024 helped better understand **Indian 6G research**; and, last but not least, the Global 6G Development Conference - IMT-2030 was instrumental to have a closer look at the **priorities of the Chinese industry and government**.

At the European level, the **Berlin 6G Conference** was instrumental in strengthening ties between Germany's national 6G program and European SNS-JU efforts. In parallel, events such as the **UKTIN International & Horizon Engagement Conference** aimed to increase the participation of UK organisations in SNS-JU activities post-Brexit, ensuring that collaboration within the European 6G ecosystem remains inclusive and robust.

This comprehensive engagement in 2024 provided a solid foundation for advancing the 6G agenda globally, enhancing collaboration, and ensuring Europe's leadership in the next generation of wireless technologies.

5 Recommendations

This deliverable aims to go well beyond activity reporting and data collection. Instead, it attempts to convey SNS ICE's point of view stemming from the insights gained from its activities and engagement with multiple stakeholders. Specifically, it provides recommendations separately for the forthcoming period of the project and the corresponding follow up, SNS CO-OP (Section 5.1); and for the various European stakeholders, this including the SNS office (Section 5.2).

5.1 For the forthcoming reporting period and project follow up

The following recommendations aim to ensure further advancements in the goals set forth by the SNS ICE project, which include fostering global collaboration, technological innovation, and alignment with industry and societal needs. This is expected to be accomplished by the follow up action SNC CO-OP since most of the proposed actions go well beyond SNS ICE which is planned to close at the end of the first quarter in the coming reporting period. The recommendations are, namely,

1. **Expand Memoranda of Understanding (MoUs) with international, European and vertical organisations.**

   Continue to establish and implement MoUs with such organisations, leveraging these agreements to initiate, again with the support of the follow up project SNS CO-OP, collaborative activities such as workshops, research initiatives, and contributions to standard-setting processes. These efforts should aim to advance global 6G innovation while fostering interoperability and reinforcing alliances from the 5G era.

2. **Sustain participation in key international events.**

   Maintain active involvement in major international events to strengthen SNS ICE's role in fostering global collaboration and disseminating insights into 6G development. Organization and participation in such events has proven extremely efficient and useful for the goals of the CSA project and the SNS JU.

3. **Repeat the successful consultation workshops for the definition of future SNS R&I Work Programmes.**

   Organize and host again the series of consultation workshops similar to those held in 2024. These workshops have proven highly responsive and effective in building consensus on critical areas such as spectrum management, AI-enhanced network automation, sustainability, and the integration of terrestrial and non-terrestrial networks. This approach ensures alignment with industry and research community priorities.

4. **Strengthen participation in EuCNC and 5G Techritory events.**

   Continue targeting EuCNC and 5G Techritory as complementary platforms to showcase progress and strengthen marketing efforts for SNS initiatives, fostering broader engagement with the 6G community.

5. **Focus on emerging verticals in the final phases of the R&I Work Programme.**

   As the SNS R&I Work Programme progresses towards technology maturity and market readiness, prioritize the identification of emerging verticals (e.g., autonomous vehicles with HD cameras). This will ensure that early adopters are effectively served, aligning technological advancements with market demands.

6. **Leverage major events to gather feedback from the audience.**

   Use events such as EUCNC to actively solicit feedback from attendees beyond the 6G-IA members and workshop participants. These insights should complement existing consultative processes and contribute to refining the SNS R&I Work Programme.

5.2 For European stakeholders including the SNS Office

To ensure Europe's leadership in the telecom sector and to maximize its impact in 6G standardisation, key stakeholders should adopt a coordinated and proactive approach. Below are tailored recommendations for key stakeholders, derived from the insights gained from SNS ICE's work (reported in this deliverbale):

SNS Office, Public Sector and Policymakers

- **P1. Invest in strategic initiatives**: Prioritize funding for projects like IPCEI-CIS to reduce dependency on non-European cloud providers, enhance data sovereignty, and support digital inclusion by expanding connectivity in underserved regions.
- **P2. Boost funding for trials and pilots**: Focus on critical areas such as AI-native networks, Integrated Sensing and Communication (ISAC), and energy efficiency to accelerate 6G development.
- **P3. Enhance international collaboration**: Integrate global research and innovation partnerships into SNS R&I Work Programmes to balance technological sovereignty with collaborative progress. Ensure programs are well-structured with commitments from both sides/regions to mitigate risks of technological autarky.
- **P4. Coordinate telco-cloud Initiatives**: Entrust 6G-IA with a leading and stable orchestration role to maximize resource utilisation and sustain long-term initiatives in telco-cloud solutions and advanced computing to be developed under the umbrella of Cluster 4, IPCEI-CIS and the SNS R&I Work programmes.
- **P5. Strengthen contributions to standardisation**: Actively encourage participation in ITU, 3GPP, and ETSI to reinforce Europe's role in global standardisation processes.

Telecom Industry

- **I1. Promote open and interoperable solutions**: Enhance competitiveness and avoid vendor lock-in by focusing on open standards and interoperable technologies.
- **I2. Invest in transformative technologies**: Channel resources into cutting-edge areas such as AI-native networks, Terahertz communication, and edge-cloud infrastructure to deliver low-latency, high-reliability applications.
- **I3. Engage in standardisation efforts**: Actively participate in standardisation groups to influence 6G specifications and contribute to a unified global consensus.
- **I4. Publish and disseminate position papers**: Leverage position papers and roadmaps to articulate Europe's 6G vision, addressing technological, societal, and environmental challenges. Disseminate these widely across digital platforms and international forums to build consensus and strengthen Europe's global influence.
- **I5. Prioritize end-user needs**: Design 6G technologies with a strong focus on end-user requirements from the onset to ensure relevance and usability.

Academia and Research

- **R1. Align research with global priorities**: Focus on areas like sustainability, AI, and ISAC to align with international goals while addressing Europe's unique challenges.
- **R2. Collaborate with Industry and SMEs**: Translate academic research into market-ready innovations by partnering with industry stakeholders and SMEs.
- **R3. Contribute to pre-standardisation activities**: Lead in critical areas like spectrum sharing and low-power communication to shape future standards.

R4. Train a skilled workforce: Develop and implement training programs to prepare a workforce equipped for the telecom sector's evolving demands.

Small and Medium Enterprises (SMEs)

S1. Focus on niche innovations: Invest in areas like AI-driven network intelligence and privacy-enhancing protocols to carve out a unique role in the 6G ecosystem.

S2. Participate in open-source and collaborative projects: Engage in initiatives such as OpenRAN and SNS-JU projects to amplify contributions and ensure scalability of innovations.

S3. Leverage replicability tools: Use these tools to showcase and expand successful innovations across European markets.

All stakeholders, to stimulate cross-sector collaboration

A1. Foster Public-Private Partnerships: Strengthen cooperation under SNS-JU collaborative frameworks and Working Groups to ensure seamless integration of efforts across sectors.

A2. Engage Vertical Industries: Include sectors like automotive, PPDR and healthcare in trials to validate use cases and ensure scalable solutions.

A3. Streamline European Contributions: Coordinate efforts to ensure impactful representation in global standardisation initiatives, reinforcing Europe's leadership in shaping the 6G landscape.

In the opinion of the SNS ICE project, by adopting these recommendations, Europe can solidify its leadership, strengthen its telecom ecosystem, and effectively contribute to the development of a robust and globally aligned 6G standard.

6 Conclusions

This deliverable *D1.2 Impact Analysis and SNS Promotional Report 2.0* highlights significant achievements of the SNS ICE project in its second year of execution and the Smart Networks and Services (SNS) initiative in establishing Europe as a global leader in 6G innovation. This deliverable consolidates insights from global trends, SNS-JU projects outcomes, and key international collaborations, underscoring Europe's alignment and contributions to the evolving 6G landscape.

The main key takeaways **strategic alignment and progress** include the fact that Europe's 6G roadmap demonstrates strong alignment with global priorities, including key enablers like AI-native networks, energy efficiency, and integrated sensing. Also, by contributing to global frameworks such as IMT-2030 and fostering synergies with strategic organisations like ITU, ETSI, and 3GPP, SNS is effectively integrating European priorities into the international 6G narrative.

Concerning the **impact on use case definition and Innovation,** SNS projects have pioneered work in areas such as autonomous mobility, immersive communications, and digital twins, reflecting high-impact verticals like Industry 4.0, automotive, and media. In addition to this, a significant increase in open-source and standardisation contributions illustrates the tangible outputs of SNS-JU funded research and their role in shaping global standards.

Through their very active involvement and participation in initiatives like 5G Techritory 2024, EuCNC 2024 and a large collection of more focused event, SNS ICE has exerted a **collaborative leadership** and helped establish collaborations with non-European partners, and fostered a globally interconnected 6G ecosystem, promoting the European vision and establishing key international dialogues.

The findings from this report emphasize the **need for sustained efforts in** the following areas:

- Strengthening Europe's position in standardisation and telco cloud development to reduce dependency on external providers.
- Bridging gaps between research findings and industrial applications, ensuring research outputs directly contribute to 6G deployment strategies.
- Enhancing KPI frameworks and establishing clearer objectives to measure the success of SNS-JU projects and their contributions to vertical industries.

As a final reflection, the SNS-JU initiative has laid a robust foundation for Europe's leadership in 6G innovation. By maintaining focus on collaboration, standardisation, and strategic alignment, SNS-JU can continue to lead the global transition to the next generation of connectivity, ensuring Europe's competitiveness, technological sovereignty, and sustainability in the digital era.

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Appendix 1: 5G Techritory 2024 - Organisation

5G Techritory doers, strategists, supporters, boosters, knowledge chests and media wizards are listed below.

- **Organised by:** Electronic Communications Office of Latvia
- **Powered by:** LIAA, European Regional Development Fund, National Development Plan, Mission Latvia
- **In Cooperation With:** ITU
- **Strategic Partners:** Ministry of Smart Administration and Regional Development of the Republic of Latvia, LMT, Nordic Council of Ministers
- **Golden Partner:** Digital Accelerator of Latvia
- **Silver Partners:** Latvia State Radio and Television Center, Freeport of Riga, Rohde & Schwarz, NATO ACT, Latvian Council of Science, Ministry of Defence of the Republic of Latvia, Nokia,
- **Bronze Partners:** Spirent, Riga City Council, Ministry of Education and Science of the Republic of Latvia, researchLatvia, Tet, VEFRESH, Mikrotik, State Research Programme, MOTE, Qualcomm, Zetes
- **Knowledge Partners:** 6G SNS ICE, 6G-IA, 6G SNS OPS, Will Townsend, IS-Wireless, Magnetic Latvia, Ministry of Foreign Affairs of the Republic of Latvia, Timo Jokiaho, Marios Nicolaou, XR Masters, NGMN Alliance, Riga TechGirls
- **Media Partners:** LETA, Nozare.lv, LA.LV, TV24

Figure 36: Partners of 5G Techritory 2024.

Appendix 2: SNS ICE Techritory 2024 - Marketing Report

This appendix includes selected items form the document entitled “Marketing Report and Statistics for 5G Techritory 2024 and SNS ICE within Forum’s Communication Activities”. Specifically, it focuses on the impact of digital marketing strategies in relation with project activities at the event.

LINKEDIN

The LinkedIn campaign was targeted to an audience based on users' job titles and interests. Campaign reached **98 771 impressions** and got **545 clicks.** The average **cost per click was EUR 1,57**, which is a bit high compared to Google and Facebook ads. So, the budget from LinkedIn was shifted to the better-performing campaigns and channels.

In addition to campaign banners, four posts **(including SNS ICE podcast)** on forum profile were advertised. Advertised post results:

POST	Amount spent	Impressions	Clicks
"Surely, one of the leading topics at a #5G event has to be….#6G! There's no easier way to catch on up 6G than by enjoying the 6G SNS ICE podcast."	50.00	8484	133
Jurģis Poriņš opinion article	40.00	8200	63
"🇱🇻#Latvian tech #startups: Showcase your innovations at #5GTechritory! 🚀"	79.00	10 445	32
Day 1 promo video post	30.00	6453	8

CAMPAIGNS TOTAL IMPRESSIONS & CLICKS:

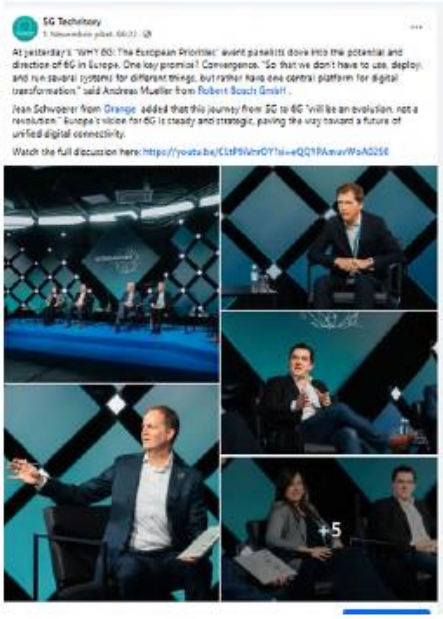
	Google	Youtube	LikedIn	Facebook	Total
Impressions	1 331 684	571 478	98 771	2 436 670	**4 438 603**
Clicks	39 497	1218	545	26 737	**67 997**

SNS ICE POSTS: Facebook, LinkedIn, Twitter

29 SNS ICE and to it related **posts** were published.

Published SNS ICE content (text copies, links to posts and post screenshots) available here.
Excel format: available here.
And several other co-creation overall agenda slides, and forum recap galleries, where SNS ICE and its members are visible/tagged in the photos, are published on the forums LinkedIn & Facebook timelines and Fb event discussion.

Published SNS ICE content (social media post screenshots) available here.



SOME STATISTICS: SNS ICE Facebook posts

Forums page has 1561 followers.

Date	Post	Impressions	*Reach*	Engagemnet
19.09.2024.	Speakers announcement amongst other speakers. Mr. Colin Willcock's card - 7th in the post (out of 55)	1448	1333	23
26.09.2024.	Highlighted event amongst top 5. "From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors" + Colin's quote	172	160	13
02.10.2024.	SNS ICE hosted panel discussion "Why 6G: The European Priorities"	178	158	7
09.10.2024.	Must attend co-creation event "From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors"	275	257	6
16.10.2024.	SNS ICE podcasts (sponsored post)	32 967	6282	50
18.10.2024.	Join co-creation event: "Shifting the Balance: Advancing Diversity in Telecoms R&D"	228	212	5
22.10.2024.	Must attend - National Initiatives event	257	249	8
25.10.2024.	A panel discussion participating Raffaele de Peppe, 6GIA Board Member & Vice Chair	255	239	11
31.10.2024.	SNS JU has announced 500M EUR in accumulated EU funding to boost 6G research and innovation!	123	116	7
1.11.2024.	Yesterday's "WHY 6G: The European Priorities" - link to Youtube recording	224	212	4
30.10.2024.	SNS ICE co-creation event with logo in the forums recap gallery	850	810	25
	TOTAL:	**36 977**	**10 028**	**159**

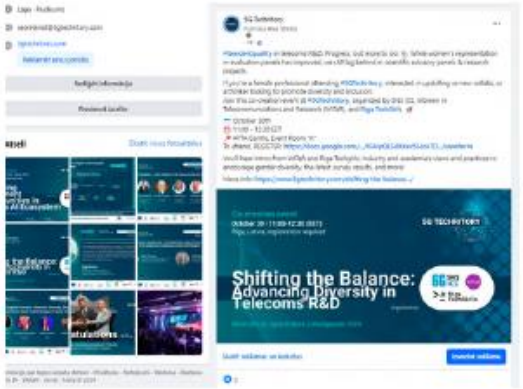
+ 2 posts in Facebook event discussion (mentioned in social media report file).

SOME STATISTICS: SNS ICE LinkedIn posts

Forums page has 2461 followers.

Date	Post	Impressions	Reach	Clicks	Engagement
2.10.2024.	SNS ICE hosted panel discussion "Why 6G: The European Priorities"	1336	902	99	147
24.09.2024.	5 co-creation events to join at 5G Techritory 2024, Shared from Newsletters also as a post on Timeline. Including - A Quote from Dr. Colin Willcock	436	282	13	33
09.10.2024.	Must attend co-creation event "From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors"	411	227	13	29
16.10.2024.	SNS ICE podcasts (sponsored post)*	8705	130	139	152
18.10.2024.	Join co-creation event: "Shifting the Balance: Advancing Diversity in Telecoms R&D"	227	121	7	16
22.10.2024.	Must attend - National Initiatives event	225	141	3	16
25.10.2024.	A panel discussion participating Raffaele de Peppe, 6GIA Board Member & Vice Chair	432	266	3	16
31.10.2024.	SNS JU has announced 500M EUR in accumulated EU funding to boost 6G research and innovation!	420	225	8	13
1.11.2024.	Yesterday's "WHY 6G: The European Priorities" - link to Youtube recording	924	565	271	307
30.10.2024.	SNS ICE co-creation event with logo in the forums recap gallery	533	262	538	550
	TOTAL:	**13649**	**3121**	**1094**	**1279**

*Statistics is different from advertising statistics because here is also organic data included. Reach is only organic (no data from advertising).



SOME STATISTICS: SNS ICE X (Twitter) posts

Forums page has 749 followers.

Date	Tweet	Views	Reactions
26.09.2024.	Highlighted event amongst top 5. "From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors" (+ Colin's quote)	48	1
02.10.2024.	SNS ICE hosted panel discussion "Why 6G: The European Priorities"	102	3
09.10.2024.	Must attend co-creation event "From 5G to 6G: leveraging key trends and 5G evolution to shape 6G for vertical sectors"	62	0
18.10.2024.	Join co-creation event: "Shifting the Balance: Advancing Diversity in Telecoms R&D"	53	2
22.10.2024.	Must attend - National Initiatives event	49	1
25.10.2024.	A panel discussion participating Raffaele de Peppe, 6GIA Board Member & Vice Chair*	817	7
	TOTAL:	**1131**	**14**

*Statistics is higher than other Tweets, because Will Townsend (moderator of the panel) and @MoorInsightsStrategy retweeted.