Smart Networks and Services International and European Cooperation Ecosystem

D1.1 Impact analysis and SNS promotional report 1.0

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Abbreviations List

Abbreviation / Term	Description
3GPP	3rd Generation Partnership Project
5G	Fifth Generation Networks
5GAA	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 NanoElectronics ActivitieS
AUV	Autonomous Underwater Vehicle
AI	Artificial Intelligence
AR	Augmented Reality
CCS	Centralized Compute System
CCAM	Cooperative, Connected, and Automated Mobility
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
China IMT_2030	China's International Mobile Telecommunications 2030
CSA	Coordination and Support Action
EBU	European Broadcasting Union
ECH Alliance	European Connected Health Alliance
ECSO	European Cyber Security Organisation
eMBB	enhaned Mobile Broad-Band
ETSI	European Telecommunications Standards Institute
EU	European Union
GA	Grant Agreement
GCOT	Global Coalition on Telecommunications
GDP	Gross Domestic Product
GSOA	Global System for Mobile Communications (GSM) Standards Association
HPC	High-Performance Computing
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IMT	International Mobile Telecommunications
IoT	Internet of Things
ISAC	Integrated Sensing And Communication

ISG	Industry Specification Group
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-R	ITU Radiocommunication Sector
JU	Joint Undertaking
KPI	Key Performance Indicator
LAN	Local Area Network
LTE	Long-Term Evolution
MEC	Multi-Access Edge Computing
ML	Machine Learning
MoU	Memorandum of Understanding
MR	Mixed Reality
MTC	Machine-Type Communications
NFV	Network Function Virtualization
NGMN	Next Generation Mobile Networks
NGO	Non-Governmental Organization
NIST	National Institute of Standards and Technology
NSF	National Science Foundation
NTN	Non-Terrestrial Networks
NTT	Nippon Telegraph and Telephone
PAWR	Platforms for Advanced Wireless Research program
PSCE	Public Safety Communications Europe
QKD	Quantum Key Distribution
R&D	Research & Development
R&I	Research and Innovation
RAN	Radio Access Network
RIS	Reconfigurable Intelligent Surfaces
SB	Steering Board
SCoDIHNet	Smart Connectivity Digital Innovation Hub Network
SDG	Sustainable Development Goals
SDO	Standards Developing Organization
SDR	Software-Defined Radio
SLAM	Simultaneous Localization and Mapping
SNS	Smart Networks and Services
SNS-JU	Smart Networks and Services Joint Undertaking
SRIA	Strategic Research and Innovation Agenda
T&P	Trials & Pilots
TAICS	Taiwan Association of Information and Communication Standards

TB	Technology Board
TCCA	TETRA and Critical Communications Association
TCI	Transcontinuum Initiative
TCO	Total Cost of Ownership
TSDSI	Telecommunications Standards Development Society, India
TTC	Trade and Technology Council
UAV	Unmanned Aerial Vehicle
UN	United Nations
URLLC	Ultra-reliable Low Latency Communications
V2X	Vehicle-to-Everything
VR	Virtual Reality
WGs	Working Groups
WP	Work Package
WRC	World Radio-communication Conference
XR	Extended Reality
ZSM	Zero touch network Service Management

Executive Summary

SNS ICE is the de facto ambassador of the SNS Joint Undertaking to the world, which entails bidirectional flow of information, i.e., i) analysis of the trends and reporting the B5G/6G Research and Innovation related activities of other regions of the world to the SNS community and ii) disseminating and promoting the R&I work of SNS projects to the rest of the world.

The first activity is addressed via the detailed analysis of global B5G & 6G trends, presented in Section 2 of this report. The significant uptake of MoUs between regions regarding 6G R&D activities, the presentation of the relevant timelines that each region has set and their alignment with the global standardization roadmaps and the focal research topics and use cases around the world, as presented in this report, provide a detailed "snapshot" of the current global landscape of B5G/6G related activities and vision for next steps. By performing a mapping between the globally considered 6G use cases and KPIs, the current status and plans of major Standards Developing Organizations (SDOs), the outlook for 6G spectrum allocation and usage (WRC 2023) and the SNS Joint Undertaking roadmap, it can be observed that European research is very well aligned with the global trends and roadmaps and European partners and key organizations remain well connected with the global ecosystem and spearhead developments in certain sections.

The global trend to establish 6G as more than just the next generation of telecommunication networks, offering ubiquitous access to everyone and everything (holistic network of networks) and combining the digital, physical and human world, is also well rooted within the EU research and innovation community. The development of the enhanced capabilities of 6G, including native AI, integrated sensing, and fully programmable and fully integrated (edge cloud, non-terrestrial, optical) networks, which will give rise to the novel envisioned use cases addressing extreme new scenarios while also providing improved and more efficient deterministic performance, are driven by common global concerns on sustainability (for 6G and by 6G), accessibility, scalability, affordability, trustworthiness and inclusiveness.

This report also provides information on the global dialogues that SNS ICE has set up to interact with the SNS JU and with the world. The project has made use of the extensive global network of its partners, foremost the one of 6G-IA, to establish communication links with key partners and associations around the world. By constantly fostering and expanding this ecosystem and by fine-tuning and promoting the key messages, results and insights from the SNS community, SNS ICE is embracing its ambassadorial role and significantly assists with the positioning of the SNS JU and EU research on B5G/6G on the global landscape.

To that end, SNS ICE partners have been actively involved in the organization, participation and dissemination of more than 12 highly impactful international events within 2023, traveling to multiple regions of the world to spread the word about the vision, structure and accomplishments of the SNS JU and to further expand the network of partners. These efforts climaxed with the organization of the 5G Techritory Forum 2023, and several targeted events within it, by SNS ICE, which had a reach to thousand of experts around the world (both physically and remotely) and set the ground for important discussions on policy, regulation, sustainability and security/privacy issues.

1 Introduction

On January 1st, 2023, the Smart Networks and Services Joint Undertaking (SNS-JU)[1] officially kick started its activities with the launch of 33 Research and Innovation (R&I) projects (Phase 1 of SNS JU), tasked with paving the way for next generation networks research in Europe. These projects will take both evolutionary and revolutionary approaches to investigating novel technologies, equipment, devices and software that will comprise future networks. The projects will also build state of the art experimentation facilities which will host cutting-edge trials in an attempt to quantify and validate the performance of various technologies, under varying network setting, and draw insightful conclusions that will shape tomorrow's 6G networks. On January 1st, 2024, 26 additional R&I projects will start their operation, while even more will be added every year according to the SNS JU timeline[1], all the way until 2030.

As it is one of EU's strongest beliefs that the entire world should be working towards a single 6G standard, it becomes critically important for the SNS JU to have strong interactions with all the necessary stakeholders and to be actively involved in all 6G networks discussions, irrespective of geographic region and technical background. Open channels of communication should ensure the constant update of the SNS JU projects with relevant world-wide developments, while also ensuring that key requirements, achievements and insights from the SNS-JU are properly packaged and communicated to the rest of the world. Such bi-directional flow of information would ensure that the EU would remain a key player in the world-wide developments for next generation networks and that EU stakeholders would remain up to date and well connected with their peers.

To that end, the SNS ICE Coordination and Support Action (CSA) project, which also started on January 1st, 2023, has the mission to become the de facto ambassador of the SNS JU to the rest of the World, and act as an interface between the SNS JU R&I projects and relevant B5G/6G oriented initiatives, programmes, associations and partnerships from various regions of the world. To accomplish its mission the SNS ICE project is working 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 comprises the first deliverable of WP1 on International Collaboration and provides a report on all relevant activities during the project's first year (January to December 2023).

1.1 Background and Context

The International collaboration approach of SNS ICE, as part of WP1, entails several different tasks linked to each other, as one acts as input to the next. In a first instance, 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 (organized 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.

[1] https://smart-networks.europa.eu/project-portfolio/

Figure 1 depicts the key activities targeted by the SNS ICE project in the context of the International Collaboration approach, and how they interlink with each other.

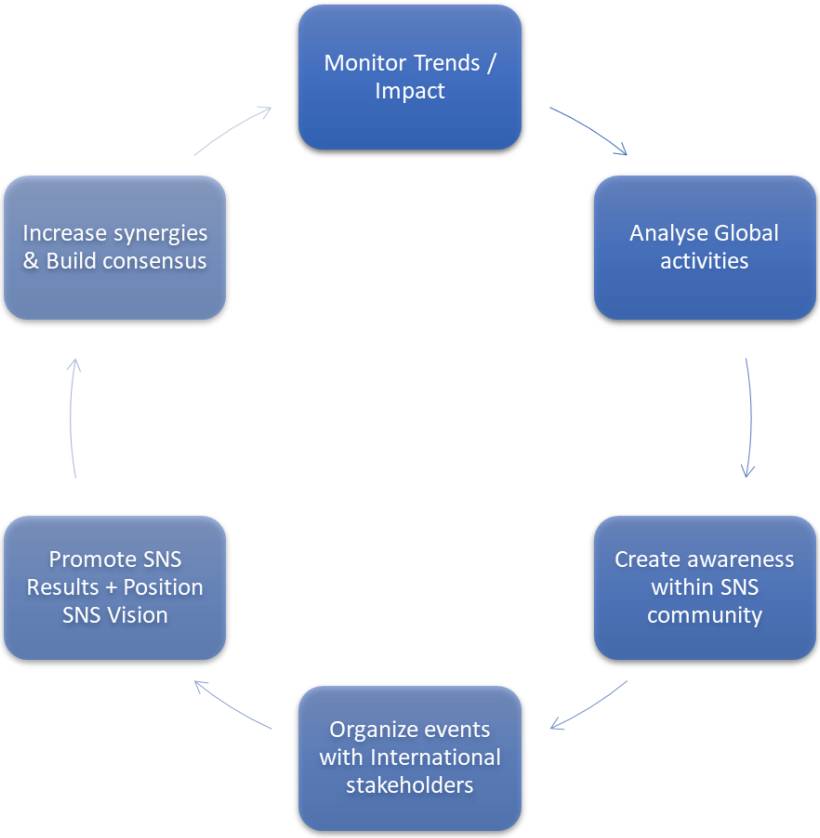

Figure 1: International Collaboration flow of activities.

1.2 Mapping of Outputs

The work on International Collaboration within WP1 is split into three distinct Tasks, each with very specific goals, as described in the Grant Agreement (GA). This deliverable reports on the progress and status of all three WP1 tasks during the first year of the SNS ICE project and provides the first trend analysis both on EU and global level, as well as an initial mapping of EU and global KPIs, use cases and enablers. Table 1 provides a mapping of the different GA components that WP1 set out to achieve and 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 2023 (starting year of the SNS projects) establishes the current global outlook towards B5G/6G technologies development and may be used as a benchmark for later comparisons (initial target vs reality).
	Mapping of EU and global KPIs	Section 2.2	This mapping of the main KPIs that EU researchers and industry consider important for 6G networks development to the ones that the rest of the world is focusing on, provides insights with regards to the alignment of the EU research roadmap with those of other regions of the world.
	Global Use cases Analysis	Section 2.3	This analysis of the use cases investigated for 6G around the world and in the EU, provides insights with regards to the alignment of the EU research roadmap with those of other regions of the world.
	Standardization planning and trends	Section 2.4	A necessary analysis of the current standardization roadmap for 6G networks to be taken into account by SNS projects.
Establish global dialogues & place SNS at a global Roadmap	Interaction with SNS projects	Section 3.1	Establishment of the functional relationship of SNS ICE with the SNS R&I projects, in order to facilitate flow of information in both directions.
	SNS-ICE global ecosystem & road-mapping	Section 3.2	Approach to create and enhance the SNS global ecosystem (current status, plans, etc.), approach to create the SNS roadmap and how that feeds back to the next versions of the Work Programme.
	Fine-tuning of SNS message	Section 3.3	Approach to fine-tune received information from SNS projects and to create the global SNS message.
Organize international workshops and events	Organization of international events, reporting and key takeaways and future plans	Section 4	List of events with international reach, that SNS ICE organized 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

In this section several notable developments of 2023 and B5G/6G trends are described. Section 2.1.2 . provides information on the published IMT2030 timeline of ITU-R in 2023 and how it relates to 3GPP, SNS joint undertaking and IEEE timelines. Section 2.1.2 depicts a clear uptake of 6G MoU between countries. In Section 2.1.3 the usage scenarios of ITU-R are explained, including the advances that 6G should bring for society and how this relates to IMT2020. In the final Section 2.1.4 a summary of the World Radio Conference in Dubai is provided, including the shaping of the available frequencies for IMT2030 globally. The available frequencies for IMT2030 relate to its future capability and scale.

2.1.1 Timelines

ITU-R adopted the new Recommendation on the "IMT-2030 Framework" [2]. The IMT 2030 framework lays the foundation for any radio technology that aims to be categorized as 6G. The next step is for ITU Member States to approve the Recommendation by correspondence by the end of 2023. In this framework, the high-level timeline was also provided until IMT-2030 specifications as shown in Figure 2. This is important for standardization bodies and the stakeholders involved, as it sets the high-level structure and timelines to develop input documents.

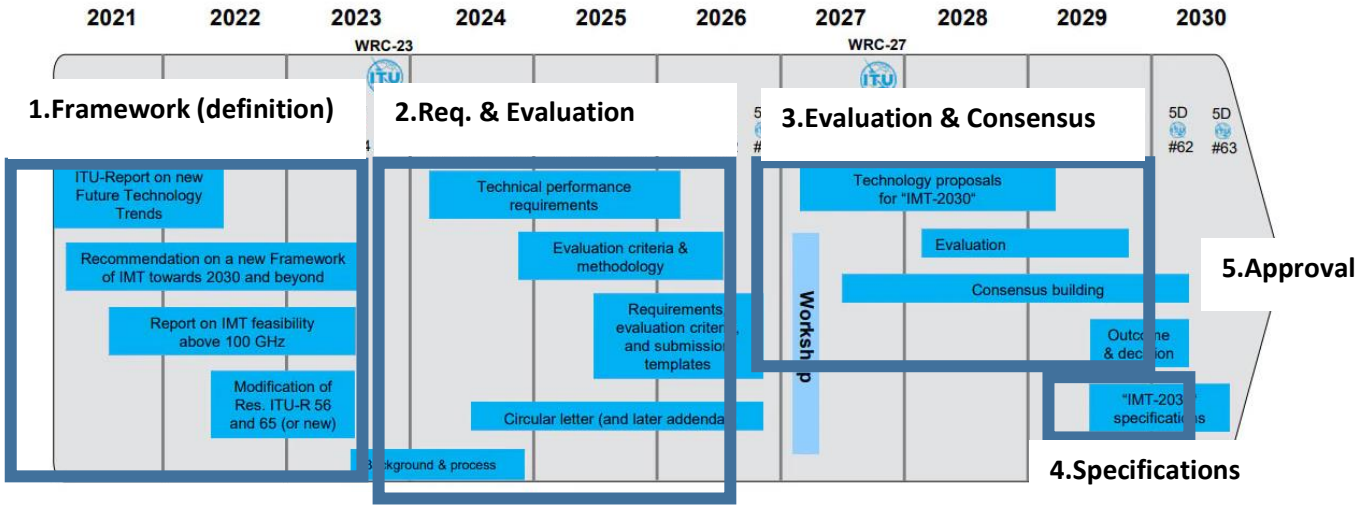

Figure 2: ITU-R high level timeline for IMT-2030.

2.1.1.1 IMT2030 specification approval (five steps)

1. Framework – This includes timeline (process), but also a high-level overview of potential use cases, capabilities and technology enablers, as the basis of IMT2030. This document serves as a basis for standardization bodies (like 3GPP) to start developing a fitting global industry technology standard.

   As a separate topic in the timeline a preliminary draft report on sub-terahertz [3] showed that IMT may be feasible above 92GHz and could be considered for IMT2030. Technical feasibility of sub-terahertz alone is not enough, IMT above 92GHz behaves very differently in coverage, blocking and propagation compared to other IMT frequencies. Consequently, many other research and business questions are still to be addressed prior to a specification decision.

2. Requirements & Evaluation criteria ('24-'26) – Technical performance indicators form the basis of the IMT-2030 specification. By setting targets, a clear differentiation is made compared to IMT-2020. Partly in parallel the evaluation criteria & methodology is developed to ensure these targets and can be

evaluated in the technology proposals later on. The performance requirements (capacity, speed, sensing capability, etc.) are an important input for World Radio Conference 2027, based on which the key 6G frequency bands will be decided.

3. Evaluation & Consensus – Consensus needs to be achieved regarding the requirements and technology proposals form the basis of the IMT2030 specification.
4. IMT Specifications – Describes the detailed specification(s) of IMT2030. Although there is a clear incentive to achieve one specification, similar to IMT-Advanced (5G), in order to achieve the global scale needed for the investments. There is precedence in previous IMT generations (e.g. IMT2000) in which several terrestrial interfaces (Dect, UMTS, CDMA2000, EDGE, TD-SCDMA) were approved as these all met the requirement of IMT2000 - 384 Kbit/s for mobile stations and 2 Mbit/s for fixed stations.
5. Final Approval of the specification by all member states of ITU.

2.1.1.2 3GPP Timeline

At the time of writing of this deliverable, the timing of 3GPP activities on 6G is not yet confirmed. However, it is clear that in a similar fashion to 5G, the specification of the first 6G standard will be a two-release endeavor.

3GPP Release 21 is expected to contain the first 6G specifications by 3GPP. However, 3GPP studies on 6G will already start in Release 20. It is expected that a 3GPP SA1 workshop on 6G use cases in May 2024 will kick-off a 3GPP SA1 Release 20 study on 6G use cases, requirements and KPIs. In this workshop, various 6G research programs and vertical associations can present their views on 6G use cases, which will then be used as input for the 3GPP SA1 work. Expectations are that a RAN/SA 6G workshop in Q1 2025 will be the start of Release 20 architecture and radio studies in 3GPP SA2 and 3GPP RAN later that year. Additional information on 3GPP and other relevant SDO plans and trends are provided in Section 2.4

2.1.1.3 SNS Joint Undertaking & member state 6G initiative timeline

The timeline of SNS JU, depicted in Figure 3, meets the timeline of ITU-R Framework including additional calls when ITU-R moves forward to 'requirements & evaluation' and 'evaluation & consensus'. In Europe, it is to be expected that the individual member state 6G initiatives (e.g., in Finland, Germany, France, Netherlands) align to the ITU-R high-level and subsequent 3GPP timeline to ensure European impact on 6G.

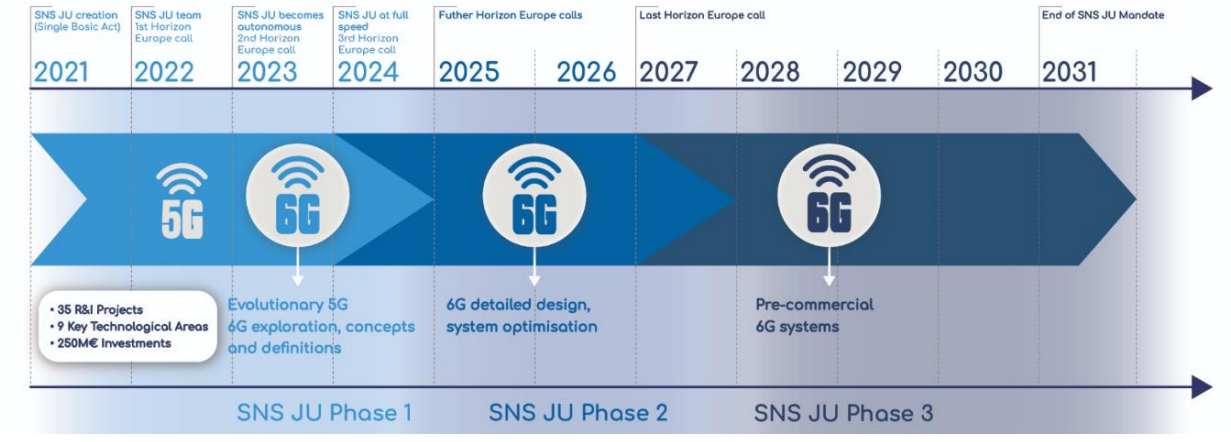

Figure 3: SNS JU Timeline [1].

2.1.1.4 IEEE Timeline WiFi 8

Introduction of IMT2030 / 6G will not be in a void. WiFi 8 final / Conditional 802 approval by EC is set on March 2028 by IEEE [4]. A more detailed timeline presented by Broadcom in CEPT, depicted in Figure 4, shows the WiFi8 R1 (802.11bn) [5] aligns with early deployments of 6G. This is relevant as WiFi8 similar to 6G aims to focus on reliability enhancements (Ultra -High Reliability), low latency (0.1ms), indoor mobility capability for e.g., XR use cases, but foremost indoor.

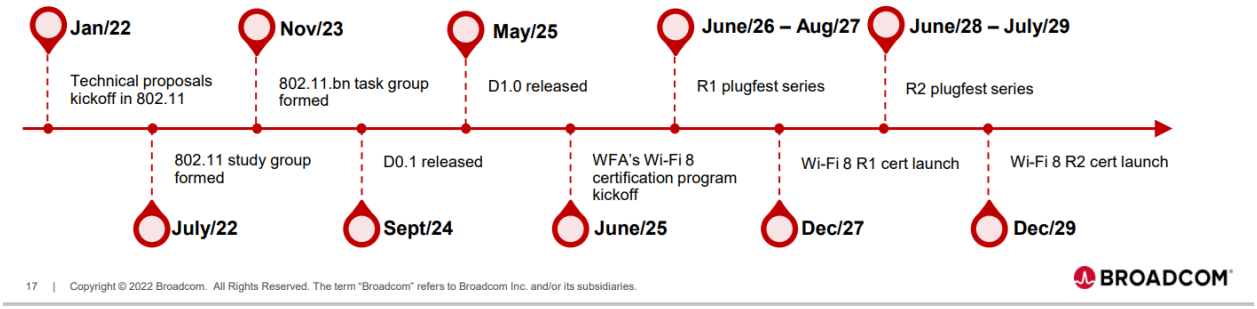

Figure 4: Broadcom presentation Path to WiFi8.

2.1.2 Uptake of 6G MoUs between countries

A clear trend is the acceleration of 6G Memorandum Of Understandings (MoU) between countries in 2023. These MoUs are typically aimed to mutually strengthen the position of each party in 6G global research and industry development. Figure 5 provides an overview of the countries / Unions part of 6G MoU or joint statement as % global GDP.

The 6G MoU in which either USA and/or EU (6G-IA) are represented form a larger share of global GDP (%) compared to China. USA and Europe have strengthened ties in October of 2023 through initiating transatlantic project (6G XCEL) on 6G & AI. Notably, USA has signed several 6G MoUs or made joint statements on 6G cooperation in 2023 (India, South Korea, Taiwan, Saudi Arabia). The largest multinational cooperation is the Global Coalition on Telecommunications (GCOT) which includes USA, Japan, UK, Australia and Canada. EU Smart Network Services signed its MoU with China (IMT-2030 6G Promotion Group) already in 2022 and recently also Taiwan in 2023.

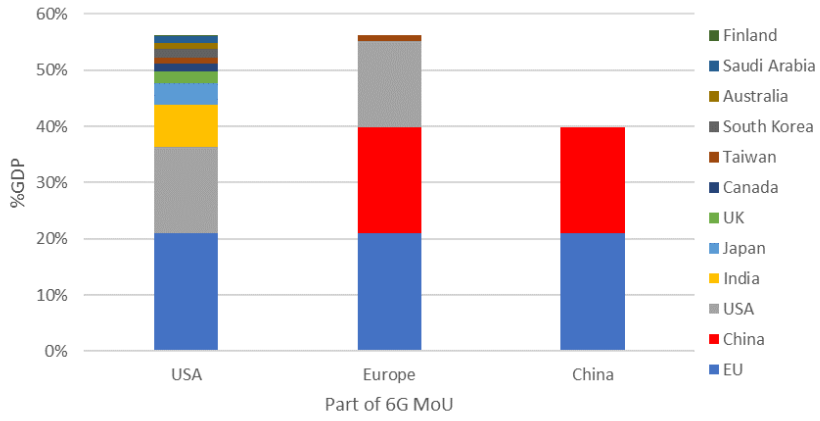

Figure 5: Countries / Unions part of 6G MoU or joint statement as % global GDP [6].

2.1.3 Usage scenarios – IMT 2030 Framework: The road to 6G

This section sets out an initial analysis of the current State of the Art of 6G use cases. The section begins by outlining the IMT 2030 framework adopted by the ITU in 2023, but not yet officially agreed. The various approaches to use cases adopted by the different key global activities in 6G are also presented[2].

On September 26th, 2023, the ITU-R Study Group 5 adopted the recommendations on the new "IMT-2030 Framework" [2]. Although ITU member states have not yet approved the recommendation, this framework represents the starting point for developing technologies aiming to address the next generation of IMT standards.

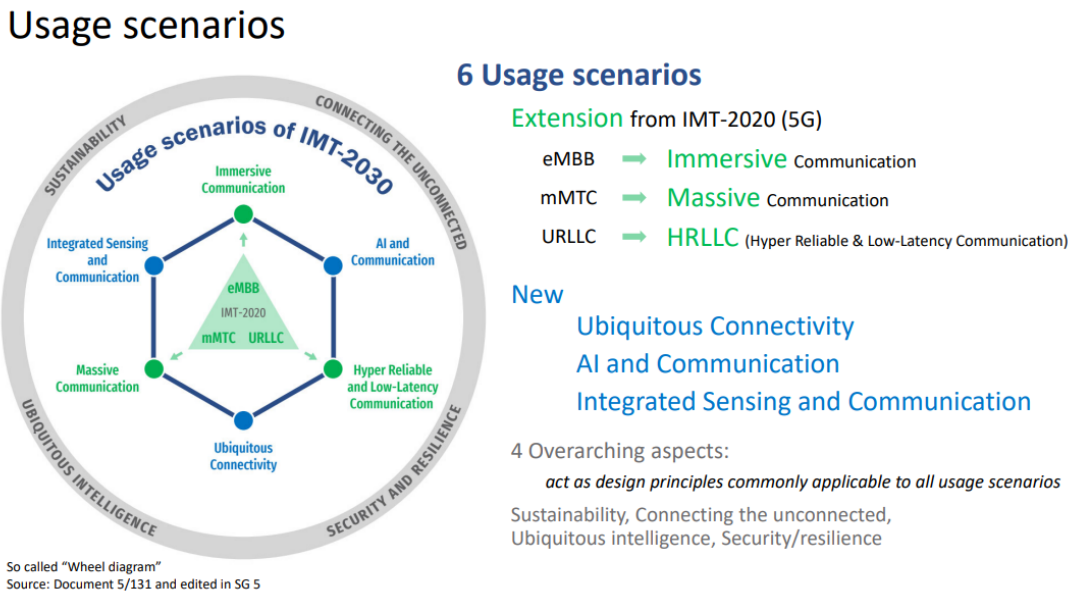

Figure 6: Usage Scenarios IMT 2030 Framework [12].

In this framework, the ITU-R presents 6G usage scenarios, as shown in Figure 6. Three of those scenarios, show an evolution from IMT-2020 (Immersive Communication, Massive Communication, Hyper Reliable & Low-Latency Communication), while the remaining 3 scenarios display new capabilities (Ubiquitous Connectivity, AI and Communication, Integrated Sensing and Communication). Furthermore, these 6 '*usage scenarios*' or '*use-case families*', are supported by four "overarching aspects" or goals (sustainability, connecting the unconnected, ubiquitous intelligence, security and resilience). These overarching aspects act as design principles, and therefore are embedded in all of these usage scenarios.

- Immersive Communication**:** Covering use cases which provide a rich and interactive video (immersive) experience to users, including interactions with machine interfaces.
- Hyper Reliable and Low-Latency Communication**:** Covering specialized use cases expected to have more stringent requirements on reliability and latency. These use cases typically focus on synchronous operations, where non-compliance with these requirements could lead to severe consequences for the applications.
- Massive Communication**:** Focuses on connecting a massive number of devices or sensors for a wide range of use cases and applications.

[2] The information presented related to the different key global activities is aimed at depicting the different approaches and key aims. Consequently, the list is not exhaustive and should not be considered as such. For further details, refer to the original documents.

- Ubiquitous Connectivity**:** Aimed at enhancing connectivity to bridge the digital divide. Connectivity could be enhanced, inter alia, through interworking and convergence with other networks/systems.
- Integrated Artificial Intelligence and Communication**:** Focusing on distributed computing capabilities and AI-powered applications. It enables unprecedented and specialized use cases by leveraging data collection, local or distributed compute offload, and the distributed training and inference of AI models across various intelligent nodes, such as transmission reception points (TRxPs) and devices in IMT-2030.
- Integrated Sensing and Communication**:** Facilitating new applications and services requiring sensing capabilities. Its goal is to offer wide-area multi-dimensional sensing that provides spatial information about unconnected objects as well as connected devices and their movements and surroundings.

2.1.4 WRC 2023 HIGHLIGHTS

This ITU World Radio Conference 2023 in Dubai was the first conference under female ITU leadership (Secretary General Ms. Bogdan-Martin – a US representative) since its founding in 1865. ITU adopted a resolution titled "Declaration on Promoting Gender Equality, Equity and Parity in the ITU Radiocommunication" showing the same progressive change. WRC has been important for harmonization of frequency allocations for 5G, 6G and direct to device mobile satellite. The key topics on WRC2023 are on i) expanding 5G radio frequencies to improve coverage and capacity which in the long run will be re-farmed to/shared with 6G and ii) defining the agenda items for the World Radio Conference 2027 for 6G.

The available spectrum balance per IMT region for 5G & 6G is also important to note in the timeframe up to 2030. As industry cellular competitiveness of regions is facilitated by the amount and harmonization of spectrum. In this area China was the first to allocate the full 6GHz spectrum for IMT (5.5G). However, during the recent World Radio Conference Europe showed more interest than other regions in some degree of co-existence with Radio Local Area Network (WiFi). It reflects the differences in history, existing frequency allocations and industry interests per region.

2.1.4.1 Additional frequencies for improved 5G coverage, capacity & further harmonization up to 2030

To support global growth in usage of 5G services in a cost-effective manner, additional frequencies are needed in a harmonized approach. This is important to understand, as 6G will not be introduced in a greenfield, but on top of 5G services and overtime substituting 5G (and previous generations). In the timeframe up to 2030 5G/5.5G will be the main technology to carry this development, while beyond 2030 this will gradually shift towards 6G.

Coverage (low frequencies below 1GHz)

Additional low frequencies could be used for IMT to improve mobile services rurally, to reduce the digital divide. These low frequencies are today typically used by broadcasters. Allowing co-existence with IMT could impair broadcast services. In the provisional final acts of WRC resolution 235 [7] UHF (470 - 694MHz) broadcast remains primary in region 1 (Europe & Russia), but IMT is allowed usage on a secondary basis if it does not result in harmful interference. This position will be reviewed in WRC2031.

Additional Capacity (upper-band 6GHz))

Upper-band 6GHz (6.125 - 7GHz) has been assigned to 5G by China, whereas US has chosen this band for unlicensed (WiFi). Depending on the decision per region, it will benefit the proliferation of WiFi6 or 5G more. In WRC2023 5.6A12 [7] provisional acts, it is declared that this band can be used for IMT in 60% of the population according to GSMA [8], but also establishes that these frequencies are used for Radio Local Area Networks (WiFi6). No details are included whether and how this co-existence is managed by e.g. imposing (dynamic) power emission restrictions. Additionally, some countries may decide later to opt-in to the framework in World Radio Conference.

2.1.4.2 Global harmonization around pioneer 5G band 3.5GHz

The 3.5GHz band is the main capacity layer and pioneer band of 5G. but there is quite some variation globally. The resolution for global harmonization of 3.3-3.8GHz in Europe, Middle East and Americas benefits the 5G services in each region, but also the ecosystem as a whole. 6G Global Harmonized Bands studies are targeted for World Radio Conference 2027.

For 6G the study of the global harmonized bands (4-15GHz) is a key a topic resolution [7]. Three IMT2030 candidate bands are identified: 4.4-4.8GHz; 7.125-8.4GHz (or parts thereof) and 14.8-15.35GHz. It should be noted there are differences per IMT region and concerns for these candidate bands. The frequencies between 4.4-4.8 and 7.125-8.5 GHz are deemed important as it allows leveraging existing 5G infrastructure for 6G. This facilitates a competitive upgrade path for existing 5G mobile operators to 6G as it protects 5G investments and still offers ability for new 6G services. However, these identified bands for IMT2030 are allocated today for important existing primary services globally. For World Radio Conference 2027, studies are considered for sharing, compatibility and technical conditions. This will be a challenging study involving existing stakeholders and IMT stakeholders in each region.

2.1.4.3 Sub-Terahertz for future IMT development World Radio Conference 2031

The need for larger contiguous blocks of spectrum is identified for ultra-low latency and very high bit-rate applications of IMT [7]. Higher frequency ranges are identified for studies in World Radio Conference 2031 namely: 102-109.5GHz, 151.5-164GHz, 209-226GHz and 252-275GHz.

Future technology development, like advanced antenna systems, may allow more efficient use of this spectrum. Still, in order to do so, first compatibility studies need to be performed with existing services. Especially as “there should be no additional regulatory or technical constraints imposed on services to which the band is currently allocated on a primary basis“ [7].

2.1.4.4 Study for WRC2027 Direct connectivity between satellite and IMT to complement coverage

The definition of a direct to device mobile satellite study also plays an important role, as this development promises several benefits for society. It aims to decrease the digital divide for people and activities living at the edge of cellular coverage in many areas of the world. It may improve (3D) connectivity for UAV which are limited, due to coverage only by terrestrial systems during flight in many areas of the world. For higher populated / income areas it should offer new opportunities and better infrastructure resilience needed for the technology which becomes the digital bedrock of society.

Allocation of (existing) harmonized IMT frequencies & standardization should enable affordable mobile satellite services, standard smartphones and IoT devices for a single market. This also offers convenience for people to use a single smartphone / IoT device regardless of the cellular coverage.

2.2 Mapping of EU and global KPIs

In this section, an overview of the next generation networks capabilities as viewed around the world, is provided. More specifically, the views around performance & sustainability requirements are shown. First an abstract of the NGMN view that these requirements should take a holistic approach into account. Next are the new and enhanced capabilities of the ITU-R framework, introduced and different views are given in the subsequent sections.

2.2.1 Holistic approach in requirements beyond connectivity

NGMN views that performance & sustainable 6G requirements should be set in a holistic approach, as depicted in Figure 7 [9]. Having high performance in 6G network is only beneficial if it benefits / meets future application demands. Consequently, to ensure end to end requirements on application level, also (edge)cloud and user equipment should be included – as this is where the application is hosted. So, the application is not something outside of the 6G network anymore. This is a material development as this approach was only taken for operator owned applications or public safety / emergency services in previous IMT generations. Now this approach is also foreseen for diverse private owned applications in various sectors.

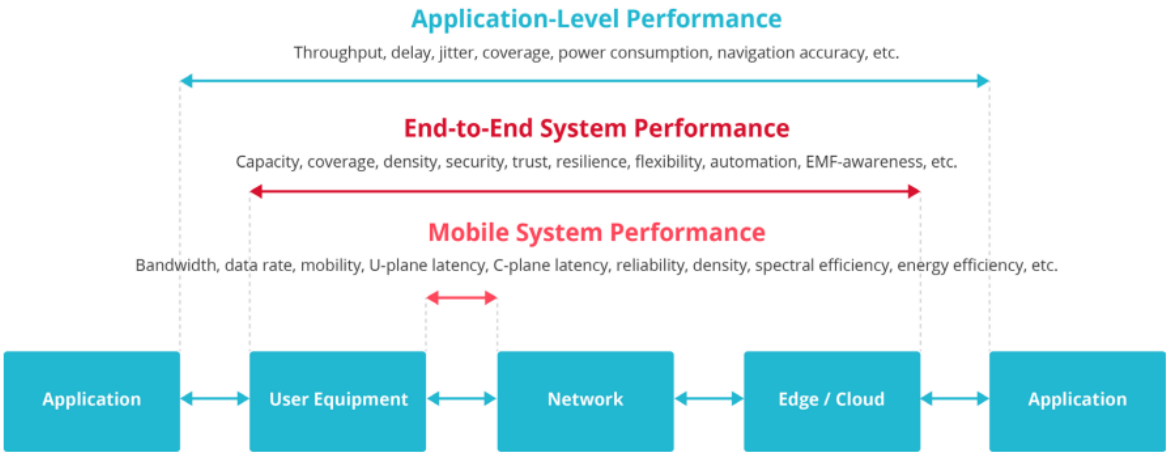

Figure 7: NGMN Holistic approach of 6G requirements [9].

2.2.2 New and enhanced capabilities of IMT-2030

ITU-R makes a split between enhancing nine existing IMT2020 capabilities and six new capabilities, as depicted in Figure 8. All of these capabilities relate to the enablement of previously introduced usage scenarios / use cases (Section 2.1.3). These capabilities and values are subject to research and investigation but do provide similar structure to compare views of different organizations.

A disclaimer needs to be stated on new and existing capabilities mentioned in ITU-R Framework of IMT2030 [10], all of these are still subject to research and development. They are only to provide guidance and structure for other organizations at this stage. For each usage scenario single or multiple values would be developed in future ITU reports / recommendations.

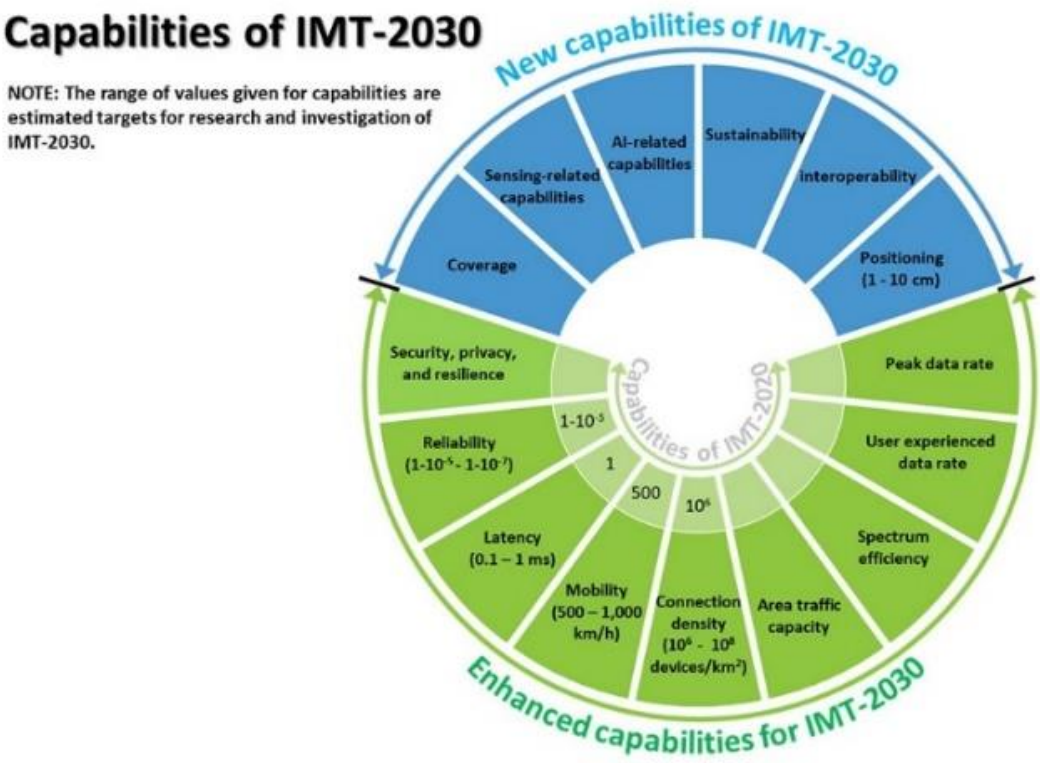

Figure 8: New and Enhanced Capabilities of IMT-2030 [10].

New IMT2030 capabilities [10]:

- Coverage**:** Although it may seem odd, the explicit focus on coverage is new compared to IMT2020. Not only to provide coverage to connect the unconnected, but also for low power / cost IoT, critical – demanding services, indoor, for airlines / unmanned aerial vehicles, etc.
- Sensing Has long been a separate technology – in IMT2030 the integration is considered with communication (Integrated Sensing And Communication - ISAC). The capability could enable "extremely high accuracy positioning, tracking, imaging (e.g., for biomedical and security applications), simultaneous localization and mapping, pollution or natural disaster monitoring, gesture and activity recognition, flaw and materials detection."
- Artificial Intelligence (AI): A capability is needed to optimize the further complicating radio interface in very complex dynamic environment for demanding services – for this AI will be needed. The most complex demand is enabling sensing on the radio interface. The capability does not stop at the radio interface, it should offer benefits in optimizing the radio network and application running on the 6G network.
- Sustainability**:** Reducing energy per bit is a long-standing focus, but being able to keep the total energy consumption as low as possible is new. The UN Sustainable Development Goals (SDG) offer a wide definition: including societal, economic and environmental sustainability. IMT2030 capability may benefit the sustainable transformation of other sectors. The approaches on sustainability in different initiatives have been very diverse.
- Interoperability: Interoperability is one of the most significant challenges in such a ubiquitous connectivity/compute environment (smart environments), where different products, processes, applications, use cases and organizations are connected. Interoperability is very important to enable innovation and scale in demanding usage scenario's & applications. Key discussions will be how to approach interoperability with multi (edge)cloud, the unbundling of the radio access network and with AI (supporting) services.

- Positioning 1-10cm**:** High-accuracy positioning (1-10cm) is a new capability compared to IMT2020 – to provide ever higher performance / efficient 6G networks the positioning of user equipment is needed. This is new compared to previous IMT in which very low accuracy positioning through triangulation was an (optional) add-on.

Enhancement of existing capabilities [10]

- Security, privacy and resilience**:** To support digital society this capability should be enhanced as new threats and demands are integral to the expected increased dependence of society on 6G networks. The 6G networks are designed as foundation for trust of users, companies and society.
- Reliability ($1\text{-}10^{-5}$ – $1\text{-}10^{-7}$): The increase in reliability may be needed for new applications in various use cases, but also for the new capability high-accuracy /resolution positioning.
- Latency (0.1 – 1ms): Further decreasing latency allows IMT to be part of measurement / control loops in systems which need sufficient time for computation & decision making (logic).
- Mobility [500 – 1000 km/h]: This enhancement may be needed to support high mobility transport, like maglev trains, hyperloop, planes. Some differentiation maybe given, as the performance capability of the 6G network may differ between 500 km/h and 1000 km/h.
- Connection density [10^6-10^8 devices/km^2]: Capable density may be further improved to also support a simpler class (very low energy / cost) IoT devices.
- Area traffic capacity**:** The expected traffic growth up to 2040 requires enhancement of area capacity.
- Spectrum efficiency: As spectrum is a very scarce resource and given the high demand – there is a clear need to further improve efficiency in IMT frequency bands.
- User Experienced data rate**:** This enhanced capability is needed to support extremely high bandwidth services such as extremely immersive XR and holographic communications.
- Peak data rate: Further improvement may be needed indoors to support specific niche use cases / device to device applications.

2.2.3 Views on new capabilities

Prior to the publication of the ITU-R framework, already many organization have published their views [11][12][13][14]. These views are not contradictory, but highlight different goals, priority or aims to be achieved with each capability. Typically, the new capabilities do not have (yet) a KPI or validation methodology. Differences are typically seen based on the foreseen use. Below some of the views of different regions per capability.

Coverage

- Bharat (India) emphasized that the integration with satellite should offer broadband 'coverage for the vast rural hinterland of India, so that every Indian has access', while also providing coverage up to 10km in the air for Unmanned Aerial Vehicles (UAV).
- Promotion Group of China IMT_2030(6G) follows the same reasoning on aerial coverage and connecting the unconnected. They broaden the subject towards 3 billion people which are today unconnected and coverage of high frequencies (needed for dense cities / advanced applications) [13].
- Networld Europe Strategic Research and Innovation Agenda (SRIA) has a similar view on the role of satellite to extend coverage of 6G for the unconnected, but also as a fallback infrastructure in case of natural disasters and for autonomous underwater vehicles (AUV). Next to the addition of 3D coverage for aerial coverage, also underwater networks are added [11].
- NextGAlliance (USA) sees also a role for different cellular topologies in 6G to extend coverage, meaning mesh-networks and embedded subnetworks [14].

Sensing

- Networld Europe Strategic Research and Innovation Agenda (SRIA) views high-accuracy sensing in an integrated approach both user equipment (human, robot, vehicle) and network can cooperate for an integrated view – to increase safety of robots, extend the view of humans etc. Also, the use of AI is seen as integral to the sensing capability.
- Hexa-X made an extensive report with various models, concepts, concluding that high-accuracy / resolution (@1THz) sensing will come later in time. Also, the view is taken that sensing can contribute to trust, inclusiveness and sustainability, but (also) that the processes on trustworthiness of a sensing function need themselves further study [15]
- NextG Alliance highlights the use of sensing in combination with AI to ensure safer, better operations of robotics in their whitepaper 6G & Robotics. Especially when these are close to humans in factory and hospital settings. A strong remark is made that, the different AI regulatory regimes need to address in system design [16].
- Promotion Group of China IMT_2030(6G) white paper on capabilities mentioned precision up to a centimeter level and a high detection rate / low false probability (varying per scenario) [12][13].

AI Native Network

- Hexa-X views 6G as the trustworthy platform for AI algorithms running on top *and* in the network. Hence it suggests open interfaces and data structures that are aligned with the requirements of AI applications. The trustworthy operation of AI functions is also covered in the report [17].
- From China Net4AI aims to also leverage deeply integrated AI in 6G to provide (advanced) AI services to various industries. Also, it highlights the need / challenges to provide Quality Guarantees for these AI services [18][19].
- NG Alliance AI highlights the transition from centralized compute towards distributed up to local (user equipment). Several times the need of training data up to user level is mentioned, but also the challenge to provide adequate level of privacy. "Datasets from mobile network operators are highly proprietary and are likely to remain so." Hence an approach of "synthetic data based on realistic emulations in digital twins" is considered [20].

Sustainability

- Hexa-X has quantitative targets of sustainability with technology advances. For example, there should be a 90% improvement in energy efficiency compared to 5G. In terms of economic sustainability, a 26.4% reduction of the total 6G network Total Cost of Ownership is targeted compared to 5G. 6G-powered ICT solutions have the potential to help other sectors reduce GHG emissions by almost 30% [21].
- NextGAlliance sees that the step from efficiency towards net-zero should be strived for. Not only energy, but also "including the usage and pollution of air, water, and land through ICT technologies" are taken into account. Next to striving for energy efficiency per bit, also monitoring is needed to ensure energy saving features are delivering the results [22][23].

Interoperability

- Hexa-X states that the 6G system is part of a diverse setup of networks and existing management and security frameworks, requiring interoperability and integration especially in terms of local management and orchestration of compute, AI capabilities and additional resources (e.g., frequency) [24].
- NGMN highlights "6G era is the development of network disaggregation and an open, interoperable cloud native architecture" also mentions backwards compatibility with 5G [25].
- NextGAlliance positions interoperability as a key enabler to achieve broker-less distributed computing with network and cloud providers, application developers, service providers, and device and equipment vendors. All have a role to play in achieving the vision of distributed 6G, in which "The right level of

harmonization in the ecosystem is key to supporting scalability, as well as the innovation needed for North American leadership in this area" [26].

Positioning 1-10cm

- Networld Europe SRIA, Next G Alliance, TSDSI and IMT promotion groups indicate that positioning should be in the order of 1 cm. Some further differentiation is given by NextGalliance on all six degrees of motion.

2.2.4 Views on enhanced capabilities

In general, most of the organizations reviewed in this report present more or less similar views for the considered enhancement of 5G capabilities. Higher peak data rates (for Holograms, digital replication) & user experience rate are supported for new demanding applications (up to holograms) – although NGMN is critical on that aspect and notes that economic / energy constraints should be carefully taken into account in the feasibility study. Also, a similar view on area capacity to grow up to 1 Gbps / m2 (100x IMT2020). Further advent of (zero-energy) IoT drive the upper limit of connection density to 10 per m^2 where the Chinese IMT promotion group is more demanding with densities up to 100 per m^2.

Latency requirements of 0.1 ms and reliability of 10^{-7} – 10^{-8} are strived for, as IMT2030 is targeting increasingly critical processes (e.g., wireless factory). Very little comparable data on Spectral Efficiency could be found, as this highly depends on the underlying assumptions / models and definitions. Table 2 provides an overview of the numeric targets for seven main KPIs, set by different organizations around the world.

Table 2: Overview views enhancement capabilities IMT2030 over IMT2020.

	IMT2020	IMT promotion group (China)	Networld SRI (Europe)	NextGAlliance (USA)	B5G (Japan)	TSDSI (India)
Peakrate (Tbps)	**0.02**	**0.5-1**	**1**	**0.5-1**	**>0.1**	**0.5-1**
User experience rate (Gbps)	**0.1**	**1-10**	**10**	**1**	**10-100** (1 everywhere)	**10**
Latency (ms)	**1**	**0.1-1**	**0.1**	**0.1-1**	**0.1**	**0.1**
Mobility (km/hr)	**500**	**1000**	**1000**	**>500**	**<1000**	**<1000**
Reliability	**10^{-5}**	**10^{-7}-10^{-8}**	**10^{-8}**	**10^{-8}**	**>10^{-7}**	**>10^{-7}**
Area traffic capacity (Gbps/m2)	**0.01**	**1**	**1**		**1**	
Connection density (devices / m2)	**1**	**10-100**	**10**	**10**	**1-10**	**10**

2.3 Global Use cases and Trials & Pilots analysis

In this section, we provide an analysis of the use cases investigated and the trials and pilots carried out for 6G around the world and in the EU. The goal is to provide insights and illustrate the alignment of the EU research roadmap with those of other regions of the world.

2.3.1 Use cases key global activities in 6G.

In the last years, different global organizations have published their views regarding use cases and requirements for the next generation of mobile communications. Some of these organizations have been well-established for a long time, like the Next Generation Mobile Networks (NGMN) forum [9]. Others have emerged in different

regions of the world or are evolutions of 5G research initiatives established earlier: Smart Network and Services (SNS) in Europe, U.S.A. with ATIS Next Gen [27], China with the IMT 2030(6G) Promotion Group [28], Japan with the Beyond 5G promotion consortium, South-Korea with 6G Forum[3] , and Bharat with Technology Innovation Group on 6G (TIG-6G) [29]. These initiatives, which are also depicted in Figure 9, comprise the key network operators, manufacturers, research institutes, and universities of the respective regions.

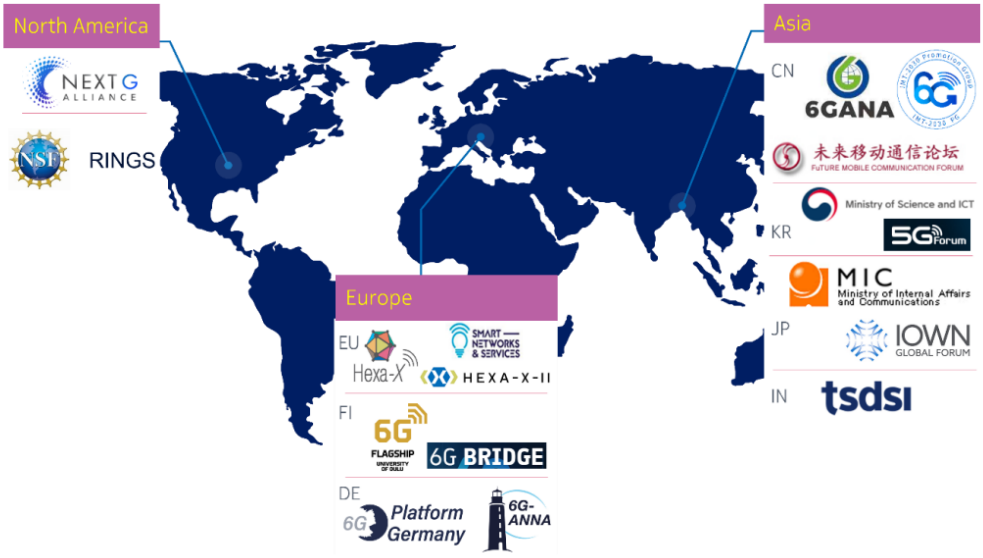

Figure 9: World map of key global activities in 6G.

In the following sections, the diverse approaches to use cases adopted by these organizations are presented, starting with NGMN as a global movement, followed by the different regional approaches identified.

2.3.1.1 NGMN

The Next Generation Mobile Networks (NGMN) alliance released their first deliverable on this project in April 2021 [30]. More recently, the alliance published a deliverable on 6G use cases and analysis [31] and 6G requirements and design considerations [9]. In this last deliverable, NGMN outlined four classes of use cases based on their common characteristics.

- **Enhanced human communication:** Including immersive experience, telepresence and multimodal interaction.
- **Enhanced machine communication:** Including robotic communication and interaction.
- **Enabling Services:** Such as positioning, mapping, automatic protection, smart health and manufacturing.
- **Network Evolution:** Such as Native Artificial Intelligence (AI) exposed as a service, energy efficiency and coverage.

2.3.1.2 Europe

Hexa-X flagship project was the first European-scale project offering a view of the research challenges beyond 5G. Hexa-X was one of the 5G-PPP projects under the EU Horizon 2020 framework. The project aimed at developing a 6G vision and an intelligent fabric of technology enablers connecting the human, physical, and digital worlds. Within their dedicated Use case deliverable [24], Hexa-X defined and described 27 use cases focusing on the end-user perspective. These use cases were divided into 6 families, as depicted in Figure 10.

[3] http://www.5gforum.org/html/en/main.php

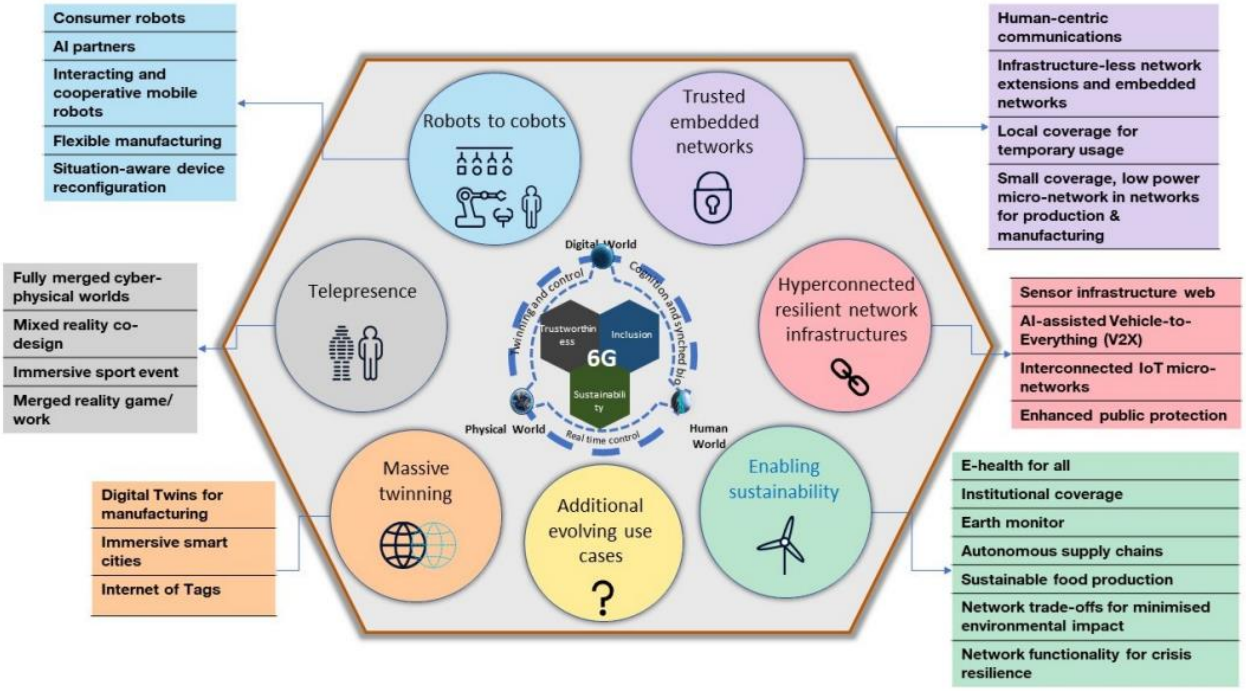

Figure 10: Hexa-X use cases.

- Telepresence: The purpose of the use cases classified in the Telepresence use case family ([24] - section 4.2.4) is the ability to be present anytime, anywhere. These use cases allow people to interact with each other as well as with the physical and digital items around them.
- Robots to Cobots: 6G is expected to witness the generalization of collaborative robots (cobots) interacting and collaborating with humans in a shared area. Within the Robots to cobots use case family ([24] - section 4.2.5, [32] section 2.1.3), the focus is on the increased utilization of Artificial Intelligence (AI) and the potential of dependable communication [33] and collaboration among robots (in both consumer and industrial use cases), either mobile or static, and humans.
- Trusted Embedded Networks: Many use cases from the *Trusted Embedded Networks* use case family ([32] section 2.1.5) require local or private communication capabilities for very sensitive information that is tightly integrated into wide-area networks. Trusted embedded networks can be dynamically reconfigured with autonomous and intelligent enabling of service capabilities, to adjust to the type of network coverage required for the services.
- Hyperconnected resilient networks infrastructures: 6G is expected to cover different scales of networks: physical and virtualized, with different ranges, from very wide area to local and very short-range networks. *Hyperconnected resilient networks infrastructure* use case family ([32] section 2.1.4) gathers different use-cases building on this granularity, requiring a highly resilient infrastructure based on multiple networks, or networks of networks.
- Massive Twinning: An important aspect of most 6G use cases is the support for – and utilization of – Digital Twins (DT), a trend that is expected to gain significance in various domains. DT will gain more and more importance, being employed in a growing set of use cases, and this generalization of the application of DT is labelled as 'massive twinning'.
- Enabling sustainability: 6G will be an asset for various sectors to reduce their environmental impacts or to create value for society.

2.3.1.3 United States

In their paper called "6G Applications and Use Cases " [35], the ATIS Next G Alliance analyses the drivers of future applications that have the potential to influence the development of 6G. These 6G applications are expected to improve the productivity, quality, time-to-market, and cost-effectiveness of companies. Four categories of use cases were identified, as also depicted in Figure 11:

- Everyday living: 6G applications aiming at improving the quality of ordinary daily living. For example, service robots may provide health care, caregiving, indoor/local delivery services, and intelligent travel assistance.
- Experience: 6G applications targeting services in the area of Mixed Reality (MR) entertainment, human-human-machine interactions, health care (physical and psychological) assistance, real-time interactive gaming with physical interactions, classrooms powered with MR content, and robotics and XR-enriched Simultaneous Localization and Mapping (SLAM)-based applications such as in the transportation field.
- Critical roles: Applications addressing critical roles are intended to improve the quality of technology in and around health care, manufacturing, agriculture, and public safety with the use of robotics.
- Societal goals: 6G applications will facilitate the achievement of high-level societal goals and increase public safety. It is expected that 6G applications will help contribute to the fulfilling the UN's Sustainable Development Goals (SDGs). 'Digital equity' (access and benefits), reduced CO2 emissions, energy efficiency, longer-lasting batteries and zero energy devices are some of the main topics mentioned.

Figure 11: ATIS NextGen use cases and applications.

2.3.1.4 China

The IMT_2030(6G) Promotion Group published the white paper "6G Usage Scenarios and Key Capabilities" [28]. The paper identified four driving forces in the development of 6G: sustainable economic development, sustainable social development, sustainable environmental development, and technological innovation and development. The group then identified 5 usage scenarios, depicted in Figure 12, three of which are evolutions of 5G scenarios (Super Mobile Broadband, Superlative Ultra-Reliable Low Latency, Ubiquitous Machine Connection) plus two new scenarios (Quality Guaranteed Network Artificial Intelligence, Integrated Sensing and Communication).

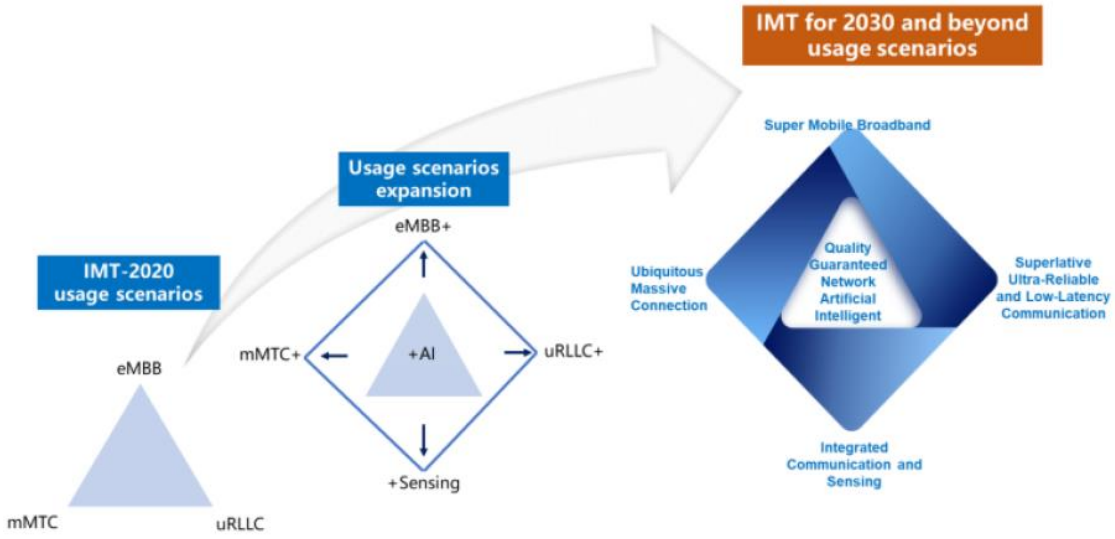

Figure 12: China usage scenarios.

- Super Mobile Broadband: An evolution of the enhanced Mobile Broadband capabilities, whose objectives are not only providing a human-centric immersive communication experience but also achieving seamless coverage anywhere in the world.
- Ubiquitous Machine Connection: Expanding the boundaries of massive Machine-Type Communications, where 6G will allow for diversified transmission rates (from low to high) in ubiquitous massive connection; allowing a full variety of applications compared to mMTC in 5G.
- Superlative Ultra-Reliable and Low-Latency Communications: Enhancing the Ultra-Reliable and Low-Latency of 5G, where there is not only a demand for lower latency and high reliability, but also demanding capabilities of medium and high-speed data transmission and ultra-high precision positioning.
- Quality Guaranteed Network Artificial Intelligence: New scenario where integrated communications and AI computing power are provided to application services and also the entire communication system operations which require intelligent learning or inference.
- Integrated Sensing and Communication: The integration of sensing capabilities will provide enhanced capabilities such as high-precision positioning, environment reconstruction, imaging and recognition. These capabilities not only open the possibility of new services but also will help to improve the performance and efficiency of communications by being able to adapt and optimize radio resources in a changing environment.

2.3.1.5 Japan

Japan's '*Beyond 5G promotion consortium'* latest version of the whitepaper "Message to the 2030s" [34] offers a different analysis perspective. Instead of focusing on *use-case families* as the other documents have done, this document builds from market trends in key industries. Based on the needs of each industry, a set of use cases is proposed from where their respective requirements are extracted. These requirements have been compiled and are presented in Figure 13.

- Mission Critical Communication**:** This usage scenario refers to those use cases which require very stringent transmission reliability and latency characteristics. Examples of use cases belonging to this

family are remote surgeries, driverless control system for railways and automobiles, and full industrial automation.

- Ultra Massive connection: Expanding on 5G scenarios, this usage scenario aims at enabling the handling of large number of devices for sensing and measuring purposes. However, it is not only for sensing the environment but also aimed at handling a large number of in-body devices.
- Ultra-Broadband Communication: This scenario expands on 5G requirements on providing extremely high data rates and low latency to support applications such as holographic communications, immersive experiences, and remote surgeries in urban areas, but also expanding to other underserved locations (e.g., aircraft, roads).
- Universal Coverage**:** This scenario refers to providing universal coverage, not only in-land (urban & rural/indoor & outdoor), but also over water and in the airspace. Apart from providing coverage and the enablement of different use cases everywhere, it helps in providing resilience in case of natural disasters.
- Ubiquitous Sensing**:** Referring to technologies that integrate sensing with communication systems. Some capabilities required are advanced localization, positioning, tracking, and mapping which can be useful for use cases such as automotive driving, warehouse management, or automatic construction.
- Intelligent Connection**:** Relates to incorporating AI capabilities into the networks, but also for applications. Examples of use cases are zero-touch operations, enhancing predictability for systems, inference for collaborative robots, and distributed learning.

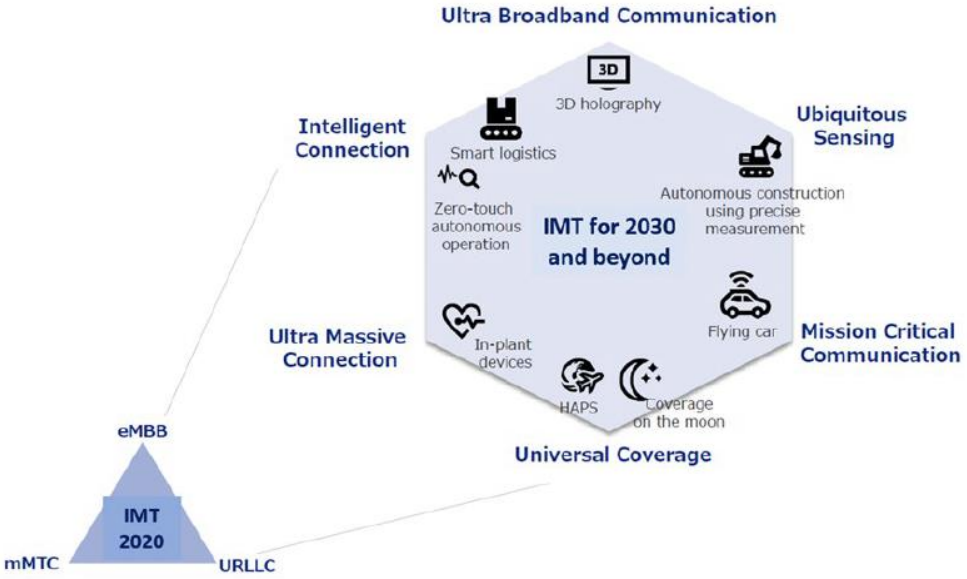

Figure 13: B5GP usage scenarios.

2.3.1.6 South-Korea

The Korean government has announced a 6G R&D strategy with the ambition to achieve "World's first 6G commercialization" and has started national R&D projects in August 2020, planning for technology trials in 2026 and commercial service in 2028[4]. A long-term network strategy called the '*Network 2030 strategy'* was announced in February 2023 by the Korean government to utilize next-generation networks such as 6G, satellite, open LAN, and quantum communication and secure the world's best 6G technology[5].

[4] https://www.koreaherald.com/view.php?ud=20220302000598
[5] https://www.msit.go.kr/bbs/view.do?sCode=eng&mId=4&mPid=2&bbsSeqNo=42&nttSeqNo=783

2.3.1.7 India

In TSDSI's whitepaper on its 6G vision [29], four main goals for 6G are outlined: Facilitate an ubiquitous intelligent mobile connected society, bridge the digital divide of the society, personalize/localize services, and native support for data ownerships and hierarchies. Furthermore, this paper introduced a list of the priority use cases for the country:

- Ubiquitous connectivity / compute Experience: Including collaborative network / compute entities assisted by semantic interoperability interfaces allowing for integration of smart city platforms, macro networks, private networks, cyber physical entities, private verticals, aerial network / compute entities and possible intermediaries.
- Enabling smart village / remote area accessibility including e-health and education: Introducing among others remote medical assistance for humans & farm animals, dynamic weather monitoring and warning systems.
- Automated Transportation: Enabling guided automated road use cases and transportation mechanisms. The aim is improving safety, relieving congestion, and increasing speeds for intercity travel.
- Industrial Internet: Where ultra-low end-to-end communication latencies and hyper reliability are key features in these use cases.
- Immersive Interactive Experience: Where VR, AR, and mixed reality (MR) experiences aim at entertainment, medicine, science, education, and manufacturing industries.
- Supply chain and logistics: With a high need for ultra-low indoor/outdoor positioning latencies for tracking in real-time.
- Surveillance for industries and civic crime control: Enabling crowd management and AI/ML-based crime prevention.
- Native AI and ML in networks: Use cases aiming for both local AI at the device and AI in the network.

2.3.2 Use cases addressed in SNS Call 1 R&D projects

Complementarily, the 6G use cases addressed by the research projects funded in the first call of the SNS—JU, are summarized in this section. As discussed in Section 3.2.3, the SNS R&I Work Programme is organized into four complementary streams (Stream A/B/C/D). Stream D projects are particularly focused on the definition of use cases where the experimental work will be carried out. However, all projects to some extent investigate this area in order to provide the right framework to their research activities.

Call 1 projects kickstarted, in January 2023, and hence mostly initial plans are reported here. Information follows from a survey that was carried out by the SNS OPS project and addressed to all 33 SNS R&I Call 1 projects. The goal of the questionnaire was to get a better understanding of the work planned to be performed in each of the projects, the challenges being addressed and the expected outcomes. This survey is part of the SNS Monitoring & Analysis Framework (SNS OPS Deliverable D1.1 [36]), while the detailed analysis of the questionnaire is reported in SNS OPS D1.2 [37]. Figure 14 below show the percentage of projects addressing each use case out of the 33 projects in the Call 1 portfolio, and with specific details for the 4 Stream D projects (Large Scale Trials and Pilots). Interestingly, the most popular use cases are:

- Medical/health, telesurgery.
- First Responder/Emergency Services.
- Digital Twins.
- Multi-sensory xR, gaming/entertainment.
- Cooperative operation of robots/drones.

Those use cases are addressed by 3 out of the 4 Stream D projects, and by a substantial percentage (above 30%) of the projects in the overall Call 1 portfolio. Besides, several projects reported activities on additional use cases not mentioned above, this includes virtual desktops (DaaS- Desktop as a Service), predictive maintenance for

airline fleet, end-to-end energy measurement and conservation system. On top of that, Stream C and Stream D have dedicated budget to run open calls at later stages via cascade funding. This will allow third parties to propose and execute additional experimental activities in, possibly, additional use cases.

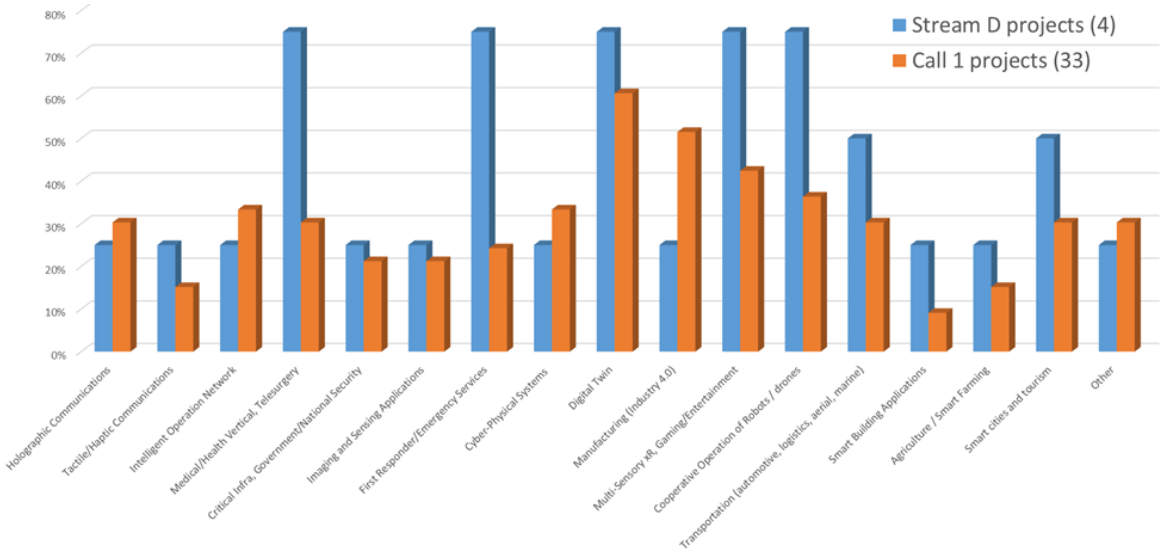

Figure 14: Use cases addressed by SNS Call 1 projects and Stream D projects.

2.3.3 Analysis of Trials and Pilots

Europe has a long record track in conducting large-scale trials and pilots for B5G and 6G technologies. Starting in mid 2017, Phase 2 of the 5GPPP already included a portfolio of 21 projects devoted to investigate the application of 5G to specific verticals (e.g., connected and automated mobility, smart cities, industry 4.0, consumer and professional services, transportation, and public services) for a total funding of 143.2 M€. Phase 3[6] began with a call on platform projects where a set of pan-European experimental infrastructures were built (5G Eve, 5Genesis, 5G-Vinni) to be used by subsequent Phase 3 projects. This included dedicated calls on Automotive Projects (Phase 3.2), advanced 5G validation trials across multiple vertical industries (Phase 3.3), 5G core technologies innovation and 5G for Connected and Automated Mobility (Phase 3.5); and 5G innovations for verticals with third party services and Smart Connectivity beyond 5G (Phase 3.6). The total number of projects in Phase 3 was 53, for a funding of 439.5 M€.

As discussed earlier, the SNS R&I Wok Programme also includes work on large-scale trials and pilots with verticals (Stream D, 46 M€) and experimental activities in SNS enablers and proof-of-concepts (Stream C, 25 M€). Concerning Stream D, the following projects have been accepted in Phase 1:

- **Trial Platform for 5G Evolution Cross-Industry on Large Scale (**Target X). The project targets key verticals such as energy, construction, automotive, and manufacturing. It plans to demonstrate, validate, and evaluate the potential of the most advanced 5G/6G technologies such as real-time communication, localization, self-description, digital twinning, and sensor-network data fusion.
- **Trials Supported By Smart Networks Beyond 5G** (TrialsNet), which will test a comprehensive set of innovative 6G applications based on technologies such as cobots, metaverse, massive twinning, Internet of Senses, in three distinctive verticals, namely, (i) infrastructure, transportation, security and safety; (ii) eHealth and emergency; and (iii) culture, tourism, and entertainment.
- **Field Trials beyond 5G** (FIDAL) targets the augmentation of human capabilities, allowing Media & PPDR vertical industry players to perform advanced technological and business validation of services such as digital twins and internet of senses/haptic applications.

[6] https://5g-ppp.eu/5g-ppp-phase-3-projects/

- **Advanced 5G Open Platform for Large-Scale Trials and Pilots Across Europe** (Imagine B5G). This project will address use cases from PPDR, smart agriculture, media, eHealth, education, transportation, logistics, Industry 4.0, and energy sectors enabled by the latest 5G Rel-16 technology enablers.

Two more Stream D projects from Call 2 are set to start in January 2024, namely, **6G Pilots and Trials Through Europe** (6G PATH), and **Evaluation and validation of connected mobility in real open systems beyond 5G** (ENVELOPE). The former will focus on several use cases spread across four key verticals: Health, Education, Smart Cities and Farming. The latter, on the contrary, will revolve on Connected and Automated Mobility (CAM) vertical services in and around vehicles, including both safety-related and other services enabled or supported by 5G.

Clearly, the use cases and verticals addressed by **Call 1 and Call 2 Stream D projects are very complementary**. In fact, this was the results of restricting the target verticals that could be addressed by Call 2 proposal to two main priority areas: (1) Connected and automated mobility (CAM) vertical and intelligent terrestrial transportation; and (2) Health, Smart Cities, Farming, or Education. This resulted from a thorough gap analysis of Call 1 projects and, also, from the identification of particularly strong vertical sectors in Europe (e.g., CAM) or with large social impact (e.g., health, farming). Interestingly, the portfolio of Stream D projects includes activities in the three vertical sector that, according to the survey conducted by SNS-OPS, are expected to be affected the most by the advent of 6G, namely, industry 4.0/manufacturing, automotive/transport/logistics and media/xR. As for the methodology for technology validation, in their trials all Call 1 projects consider both new deployments, and the re-use of existing platforms (from e.g., H2020-ICT17). In 50% of the cases, the use of (smaller scale) testbeds and lab tests is considered as well. Concerning the type of (end user) equipment used for testing/trialling, all projects employ cell phones and IoT sensors. Drones are often used too (75%), followed by modem/routers and custom premises equipment (50%). For details, the interested reader is referred to deliverable D1.2 of the SNS-OPS project [37].

Additional **Stream D projects** will be invited with **Call 3**, while no restrictions will be imposed on specific verticals. However, the proposed use-cases will have to demonstrate a **high impact in terms of environmental, societal, and/or economic sustainability**.

Beyond Europe, we have not observed comparable initiatives for large scale trials and pilots running on public funds. Admittedly, the **Platforms for Advanced Wireless Research program** (PAWR) is in place in the US. This program is aimed to enable experimental exploration of new wireless devices, communication techniques, networks, systems, and services [38]. The program is supported by the National Science Foundation (NSF) and a wireless Industry Consortium of 30 companies and associations. Even if the program includes the deployment and management of up to 4 city-scale research testbeds, the level of public funding is lower (100 M$) and it lacks the involvement of vertical companies. The Department of Defence (DoD) and the NSF are also supporting institutional-level initiatives like the **Next GEneration NEtworks and SYStems** (GENESYS) Lab [39]or the **Open6G** research centre [40]. Those initiatives include a very strong experimental component but, again, cannot be regarded as *large-scale* trials and pilots *with* verticals. From this, we conclude that in other regions such activities are mostly carried out in the context of private trials, that is, run and funded by private companies such as vendor or mobile networks operators. Even if further analysis and monitoring is required in the coming months, this may indicate that the EU retains a very strong position in the global R&I arena in terms of large-scale T&Ps.

2.4 Standardization planning and trends

To address the critical needs of European industry in communication systems, networks, and ICT systems, aligning with European policy objectives that enhance competitiveness and technological sovereignty is essential. This alignment also shapes the global standardisation ecosystem, which has seen significant achievements in mobile and wireless communication systems, ensuring interoperability, global roaming, and economic benefits.

European contributions and intellectual property rights in advanced 5G and 6G networks are crucial for maintaining competitiveness in global standards setting. The evolution of telecommunication systems, particularly 6G networks, will significantly impact business environments and citizens' daily lives, necessitating collaboration across various stakeholders, including manufacturers, operators, vertical industries, and the public sector.

The SNS ICE project, supported by 6G-IA, aims to facilitate European and international cooperation, promoting research results and informing the community about global trends and national initiatives. This project aligns with the Single Basic Act on Joint Undertakings, focusing on local, national, regional, European, and global cooperation to achieve globally accepted standards. Such a model necessitates extensive collaboration across a diverse range of stakeholders. Effective communication and robust links are essential for this collaboration, involving two primary groups:

Direct SNS-Related Stakeholders:

- SNS Projects and Members: Interaction through SNS working groups.
- SNS Operational CSA Project: The project selected for the SNS-2022-STREAM-CSA-01 call.
- SNS JU Office and Governing Board: Central administrative and decision-making bodies.
- 6G Smart Networks and Services Industry Association (6G-IA): A key player in the 6G landscape.

Related Non-SNS European and Global Activities:

Matching the SNS JU standardisation roadmap with that of Standardisation Organizations responsible for setting international standards (e.g., ITU, ETSI, 3GPP) is an essential step to ensure the interoperability and future adoption of the innovative results produced by SNS JU R&I projects.

Below, a comprehensive and detailed approach by 3GPP, ETSI, and ITU towards developing and standardising 6G is illustrated. While each SDO focuses on different aspects, their share the aim to ensure a robust, innovative, and future-proof mobile communication ecosystem.

2.4.1 3GPP'S Roadmap to 6G

- 5G Advanced as a Precursor (Current to 2024): 3GPP Release 18 marks the start of 5G Advanced, building on the 5G baseline defined in earlier releases. This phase includes learning from commercial 5G networks and supporting new market segments and use cases, providing a foundation for future 6G systems.
- Standardisation of 6G System (Starting from Release 21): Post initial studies, the formal standardisation of the new 6G system is expected to officially start from 3GPP Release 21. The first 5G Advanced release is set to be completed in early 2024, with the first basic 6G drop anticipated in 2028, followed by subsequent evolution[7].

2.4.2 ITU's IMT-2030 Framework for 6G

- Approval of IMT-2030 Framework (2023): The ITU Radiocommunication Assembly approved the IMT-2030 Framework, which sets the basis for the development of IMT-2030. This represents the initial phase in the development of 6G.
- Defining Requirements and Evaluation Criteria (2024-2027): The next phase involves defining relevant requirements and evaluation criteria for potential radio interface technologies (RIT) for IMT-2030.

[7] https://www.ericsson.com/en/reports-and-papers/white-papers/5g-advanced-evolution-towards-6g#:~:text=After%20initial%20studies%2C%20standardization%20of,2028%2C%20followed%20by%206G%20evolution.

- Supporting Enhanced and New Capabilities (Ongoing): IMT-2030 aims to support enriched and immersive experiences, enhanced ubiquitous coverage, and enable new forms of collaboration. It is expected to support expanded and new usage scenarios compared to IMT-2020, providing enhanced and new capabilities.
- Drafting Recommendations for 6G Development: The draft new Recommendation addresses trends, usage scenarios, and capabilities of IMT-2030, along with considerations for ongoing development. This forms the basis for the standardisation fora to develop the next generation of IMT standards[8].

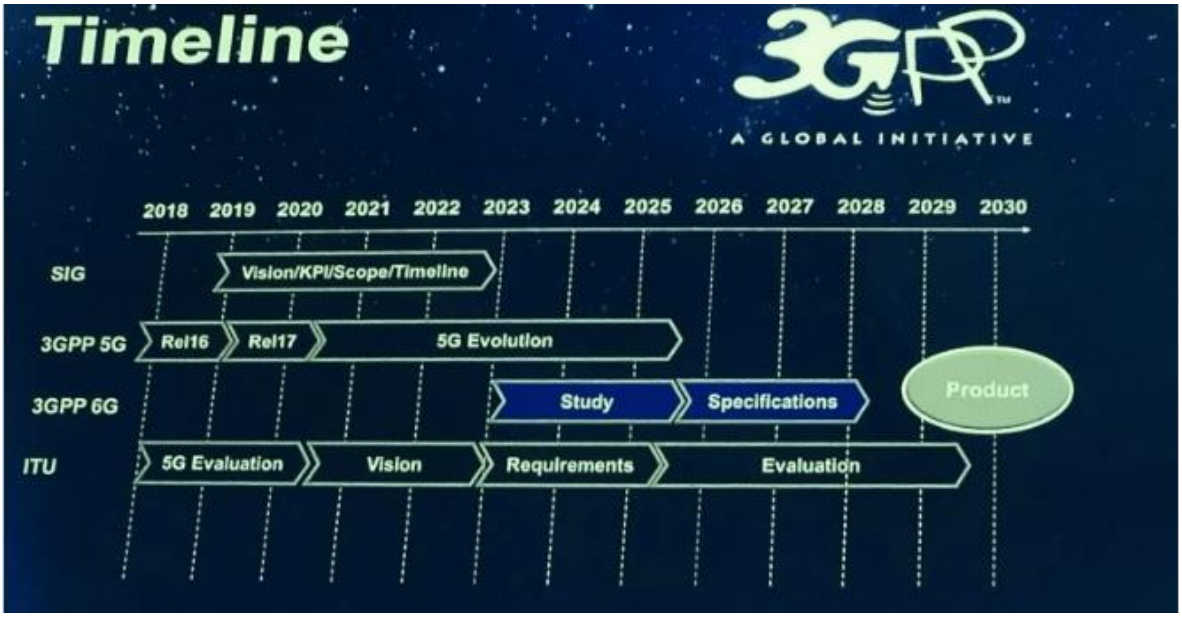

Figure 15: 3GPP/ITU 5G/6G Standardization timeline.

2.4.3 ETSI's work towards 6G

ETSI has recently established a new ISG addressing Integrated Sensing and Communication (ISAC).

- Development of ISAC Technology: The ETSI ISAC ISG focuses on Integrated Sensing and Communications (ISAC) for 6G, adding a new element of capability to wireless networks. This includes innovative use cases like object and intruder detection, fall detection, and environmental monitoring.
- Standardisation and Use Case Definition: The group will define a prioritised set of 6G use cases and sensing types, with a roadmap for their analysis and evaluation. This includes advanced use cases not expected to be covered by 3GPP Release 19, potentially to be included in future 6G releases of 3GPP. They aim to develop advanced channel models for ISAC use cases and sensing types, validating them through extensive measurement campaigns.
- Outputs for 6G Development: The group plans to provide outputs for architectures, deployment considerations, key performance indicators (KPIs), and evaluation assumptions. Two studies will be undertaken: one analysing privacy and security aspects associated with sensing data within the ISAC 6G framework and another on the impact of widespread deployment of ISAC on the UN sustainable development goals[9].

[8] https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2030/Pages/default.aspx.
[9] https://techblog.comsoc.org/2023/11/21/etsi-integrated-sensing-and-communications-isg-targets-6g/

In addition, ETSI is also currently developing new open-source components within three new groups, all building on 5GPPP research outcomes and with active collaboration with several SNS projects that have committed to using and contributing back to their software.

- ETSI TFS – TeraFlowSDN[10] is developing an open-source cloud native SDN Controller enabling smart connectivity services for future networks beyond 5G.
    - Standards Groups in scope: IETF, ISG MEC, ZSM, mWT, NFV, QKD, F5G, TC SAI.
    - EU projects using/contributing code: TeraFlow, ACROSS, FlexScale, Int5gent, SEASON, Hexa-X-II
- SDG OSL – OpenSlice[11] is developing an open-source Operations Support System to deliver Network as a Service.
    - Standards Groups in scope: GSMA, TM Forum, 3GPP, ISG ZSM, NFV
    - EU projects using/contributing code: 5GinFire, 5G-vinni, ACROSS, FIDAL, IMAGINE-B5G
- SDG OCF – OpenCAPIF[12] is developing an open-source Common API Framework as defined by 3GPP to enable API exposure and invoke in a secure and consistent manner.
    - Standards Groups in scope: 3GPP, ISG MEC, ZSM, NFV
    - EU projects using/contributing code: EVOLVED5G, 6GSANBOX, FIDAL and IMAGINE-B5G.

2.4.4 6G-IA Pre-Standardization Working Group

In this context, 6G-IA's pre-Standardisation Working Group will be instrumental in identifying standardisation and regulatory bodies to align with, such as ETSI, 3GPP, IEEE, ITU-R, and WRC. The group develops a roadmap for 5G standardisation, evaluates international roadmaps, proposes its own aligned roadmap, and influences pre-standardization and R&D timing. This strategic approach ensures that European stakeholders remain at the forefront of the global standardisation process, particularly in the rapidly evolving 6G landscape.

[10] https://tfs.etsi.org/
[11] https://osl.etsi.org/
[12] https://ocf.etsi.org/

3 Global Dialogues and Roadmap

A big part of the work carried out in WP1 of SNS ICE is to collect data from the ongoing SNS projects, to process the results and generate impactful insights on multiple different aspects (requirements, results, achievements, challenges, vision, lessons learned, etc.). Such insights should be later fine-tuned into key messages that the EU R&I community and the SNS-JU as a whole can transmit to the rest of the world to indicate highlights of its work and disseminate its core ideas regarding next generation networks. These fine-tuned messages may also be used to create a roadmap for the SNS R&I indicating the most important technological aspects according to EU researchers and highlighting the potential way forward towards the development of 6G. Such an extrovert approach with regards to the findings and vision of EU researchers would lead to global dialogues with peer researchers, industrial players and SMEs and would assists toward the development of a single 6G Standard.

As this is a multi-faceted activity, the following sections break-down the approach followed by SNS ICE partners and present the agreed way of working to achieve such global dialogues and to monitor the impact that SNS Project outcomes have on the global community.

3.1 Interaction with SNS projects and operational CSA

The issue of interaction with the SNS projects and the most effective way to collect information in order to create a global SNS message, is not trivial, as from the beginning of 2024 there will be 62 active projects, that will be further increased in 2025. This large number of projects along with the fact that there are more CSA projects and collaborative bodies (such as SNS OPS, the SNS SB, TB and WGs, etc.) "competing" for the attention of the project representatives and potentially asking them for input, creates a complex ecosystem, which should not stand in the way of efficient communication of results/insights from the projects towards SNS-ICE and vice versa (global messages from SNS ICE to the projects).

From the very beginning of the SNS programme it was agreed with the SNS OPS project, that the two CSAs (SNS OPS and SNS ICE) should have a common strategy from communication towards the projects, to minimize overlap and avoid duplication of work. As SNS OPS is the operational CSA tasked with the day-to-day support and communication with the projects, it was agreed that SNS OPS would act as the main communication channel to and from the SNS projects (in coordination with SNS ICE), while SNS ICE representatives retain their voice in the common collaborative bodies (SNS SB, TB and WGs) and may collect additional information via these bodies when necessary.

What this means, is that if a request from ICE can be scheduled well in advance (e.g., input for a specific upcoming deliverables or large international event), etc., then a request is made to the projects via one of the mechanisms of SNS OPS (such as the annual questionnaire). Moreover, SNS OPS, always consults SNS ICE partners before issuing a new request for input to the projects, asking for feedback and potential additions to the request, that would also cover some of the needs of SNS ICE. If on the other hand some more ad-hoc input from the projects is needed, or perhaps a quicker response time is necessary, then SNS-ICE partners may bring this request directly to the common collaborative body which is mostly related with the type of request (e.g., coordination level or more technical issue).

By following this strategy, the two CSA projects have ensured that both a long-term and a short-term approach for communication with the projects have been taken into account, while the constant synching between OPS and ICE ensures minimal requests made towards the projects. As an overview, SNS ICE partners have established the following channels of communications with the SNS projects:

- *SNS OPS Annual Questionnaire*: As part of the SNS OPS Monitoring & Analysis framework, a new questionnaire is issued every year towards both new and existing SNS projects (see deliverable D1.1 [36] and D1.2 [37] of SNS OPS). SNS ICE partners are included in the preparation of this questionnaire and have the opportunity to add questions towards the projects.

- *SNS Steering Board (SB) & Technology Board (TB)*: The SNS ICE project Coordinator (Kostas Trichias from 6G-IA) is actively involved in the SNS SB, where news and updates from all projects are offered and discussed, while new requests for input (or clarifications) can be made. Moreover, he has recently been elected as the SNS TB chair, which means an even more active engagement with the Technical Managers of all the SNS projects and in a position to solicit additional input.
- *SNS project WGs*: Multiple SNS ICE partners have active involvement in the SNS project WGs and may hence "harvest" relevant information from these WGs. Additionally, the WG leaders are actively reporting to the SB, about relevant highlights and achievements.
- *6G-IA WGs*: As 6G-IA is the project coordinator of SNS ICE, but also several project partners have key positions (chairs an vice-chairs) in many 6G-IA WGs, there is a direct line of communication with al 6G-IA WGs, and regular updates received on their status ad reported achievements
- *Ad-hoc events*: SNS ICE in collaboration with SNS OPS organize and/or facilitate several events for SNS OPS projects where information is exchanged and documented.

Based on the above, SNS ICE partners are in an excellent position to collect the necessary information from the SNS projects without significantly adding to the workload of the Projects and are able to monitor all key developments that may potentially lead to interesting messages for the rest of the world.

3.2 SNS-ICE global ecosystem & road-mapping

This section reports on the current status and the approach to create and enhance a truly global 6G SNS ecosystem and to stimulate consensus building. In relation with this, it also describes the roadmap to 6G in the SNS R&I Work Programme, the outcome of which fuels the role to be played by EU companies in the consensus building process and, ultimately, in the standardization work.

3.2.1 Building a global 6G ecosystem: MoUs & Letters of Intent with worldwide organizations

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. For this reason, one of the Strategic Objectives of the SNS-ICE proposal was:

> *S.O.19: Already established agreements with other regions and countries in 5G PPP (e.g., USA, Japan, South Korea, Brazil, China, India, Taiwan, etc.) will be reinforced for 6G, using MoUs and further agreements where appropriate, with new stakeholders will be established to develop synergies with other regions and countries.*

The fact that this ecosystem is already truly global is illustrated in Figure 16 below. Some of those links between the 6G-IA and peer organizations were already established under the umbrella of the 5G PPP. They have been kept alive and further strengthened on the road to 6G networks and potentially add any missing links with further key stakeholders. Specifically, **new MoUs** have been stablished with the German Platform for future communication technologies and 6G (**6G Platform**); and the Taiwan Association of Information and Communication Standards (**TAICS**), an industry organization aimed to bridge the local industry with global standard initiatives/organizations by contributing the study results or consolidated consensus and also develop local standards per request. Besides, the 6G-IA has signed an agreement with the **IMT-2030 (6G) Promotion Group**, a platform to promote 6G R&D and international cooperation which drives cutting-edge research on 6G technology and industry in China. This can be regarded as the follow up organization to the IMT-2020 5G Promotion Group, with which the 6G-IA already had an MoU in place. Last, one more agreement has been signed with the **NEXT-G Alliance**, an initiative to advance North American wireless technology leadership over the next decade through private-sector-led efforts, with a strong emphasis on technology commercialization. This follows to the existing MoU the 6G-IA had with 5G Americas. Several activities in collaboration with those organizations (e.g., the 6G EU-US roadmap jointly developed by the 6G-IA and ATIS Next-G Alliance) have already taken place.

Figure 16: MoUs with international peer organizations.

SNS ICE is also very active in increasing the active engagement of stakeholders from vertical sectors (S.O.4), associations, standardization and regulatory bodies. Several consortium members (e.g., TIM, NOKIA, TNO, EURESCOM, 6G-IA, CTTC) are strongly committed to this activity. Figure 17 provides details about all the bilateral agreements that the 6G-IA has established with such organisations. With respect to the ones listed in the SNS-ICE proposal, **additional MoUs** have been signed with the **European Broadcasting Union (EBU)**, the world's leading alliance of public service media; the **Transcontinuum Initiative (TCI)**, a collaboration between 8 European associations and projects towards the definition of the infrastructure required for the convergence of data and compute capabilities in edge industrial and scientific use scenarios; **the Association for European NanoElectronics ActivitieS (AENEAS)**, an industrial association in the field of micro and nanoelectronics enabled components and systems; and, finally, **SCoDIHNet** an initiative contributing to the European Industry Digitalisation by helping companies to improve their processes, products and services through the use of connectivity.

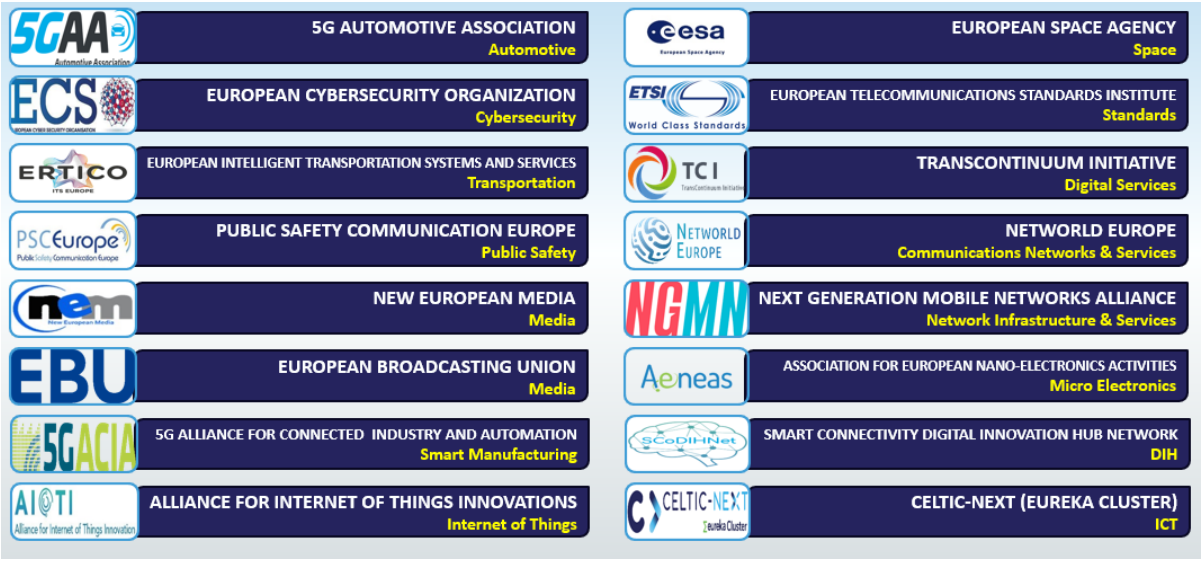

Figure 17: MoUs with vertical sectors, associations, standardization and regulatory bodies.

3.2.2 SNS-ICE/6G-IA's approach to consensus building

Globally accepted standards can only be achieved by cooperation between all relevant stakeholders and competitive contributions. International cooperation requires information exchange and consensus building around new communication technologies and use cases, e.g., from vertical industries. A dedicated Key Objective was defined in the SNS-ICE proposal: *K.O.3 Target consensus building & plan for future steps* which, in turn, included seven strategic objectives (S.O.17-S.O.23). The SNS ICE project acts as an ambassador and provides the platform to communicate and promote the European Vision for 6G networks and the key technological findings of the SNS projects at a global level. Instrumental to this are activities such as an intensive participation in international events (see Section 4 in this document), the elaboration of position/white papers, the definition of roadmaps, and collaboration towards the elaboration of joint research programmes. For the last three, this section reports the main achievements during the first year of SNS-ICE.

3.2.2.1 EU-US Beyond 5G / 6G roadmap

During the fourth Ministerial meeting of the Trade and Technology Council (TTC), which took place in Luleå, Sweden, on 31 May 2023, the EU and US administrations reaffirmed their commitment to cooperate to develop 6G networks. As a first step, the 6G Industry Association (6G-IA), the private member of the EU Smart Networks and Services Joint Undertaking (SNS JU) and the Next-G Alliance requested to provide an interim, joint, aligned 6G industry roadmap by the end of 2023. This document puts forward a comprehensive set of key strategic reflections and recommendations for 6G networks and services, capturing the views and priorities from Next-G Alliance and the SNS JU. It also offers a candidate roadmap for future opportunities through EU and US funding instruments. Further, it aims to provide directions for collaboration opportunities that will go beyond the scope of such funding instruments, assisting the academic and business stakeholders between the two sides of the Atlantic to identify mutually beneficial opportunities.

Specifically, this document analyses 6 key collaboration areas between the EU and US that could be developed considering the years 2025 and beyond. The potential areas for collaboration include: ***sustainability of 6G systems, microelectronics and 6G, cloud solutions and distributed computing, open network solutions, artificial intelligence and 6G, and trustworthiness and cybersecurity***. Besides, the participating experts (which included SNS-ICE team members from NOKIA, 6G-IA, TNO, and the CTTC) additionally identified the following areas for cooperation: (i) Joint technology Proof-of-Concepts (PoC) targeted towards selected Vertical industries; and (ii) workforce development strategies to increase the number of engineers for the development of advanced 6G technologies. This document was elaborated in Q4/2023 and will be published in early 2024. As specific short term actions for the consideration of the policy makers, the document proposes (i) to organize a face-to-face workshop between EU-US in the first quarter of 2024 to discuss the recommendations of the WP and potential feedback from the TTC meeting in December, to elaborate on possible actions during 2024; (ii) to create a concrete strategic collaboration agenda in terms of collaborative R&I actions (June 2024); (iii) to organize coordinated Proof-of-Concept towards one or two Vertical Industries; and (iv) to work to identify possibilities for common view on 6G spectrum across EU and US (June 2024).

This position paper, still in preparation, will be widely publicized and presented in a number of fora in the coming months. This includes e.g. an invited speech in the upcoming IEEE Wireless Communications and Networking Conference 2024, in Dubai by the SNS-ICE partner CTTC.

3.2.2.2 Position paper: Key Strategies for 6G Smart Networks and Services

The purpose of this document [41] is to provide a first comprehensive set of key strategic reflections and recommendations for 6G smart networks and services, capturing the views and priorities from the members of the 6G-IA. The goal is that this document will be used to further elaborate future versions of the SNS JU Strategic Research and Innovation Agenda (SRIA) as well as the R&I Work Programmes. It also aims to offer directions for collaboration opportunities for European Stakeholders that will go beyond the scope of the SNS JU.

The position paper is organized around two main priorities, namely, **6G Technological Sovereignty** which includes components and microelectronics, open SNS solutions, cloudification and distributed computing, network intelligence, security and privacy, and knowledge base; and **Sustainability,** which captures all aspects of environmental, societal and economic sustainability This document provides a brief analysis of each area and proposes concrete recommendations.

The first version of this document was released in September 2023 and presented to the members of the 6G-IA association in a dedicated webinar, and to the INTERACT COST Action in one of its plenary meetings (see Section 4.2, for details). However, it should be regarded as a "living document" where topics will be updated or highlighted (by producing specific strategic documents) in the coming years, following the technological advances, market uptake and ecosystem evolution. Several team members in the SNS-ICE project were directly involved in the elaboration of this position paper, including NOKIA, CTTC, TIM, 6G-IA, and TNO partners.

3.2.2.3 Collaboration with other world regions in the SNS R&I work programmes

Collaboration towards the alignment or definition of joint R&I Work Programmes is of utmost importance for consensus building. The ultimate goal is to achieve unified consensus framework promoting a European approach towards 6G, facilitating international cooperation with other regions having started bold 6G initiatives. The consensus achieved can then be exploited in standardisation activities. In the SNS R&I Work Programmes [42][43], international cooperation targets/has targeted the USA (Call 2023), Japan and the Republic of South Korea (Call 2024). Collaboration revolves around a well-defined set of topics of mutual interest.

As per the SNS R&I Work Programme 2023-24, the cooperation with the US focused on technologies and architectures exploring AI to facilitate global validation, adoption and standardisation of intelligent approaches; a widely accepted framework for meaningful evaluation of proposed AI/ML-powered solutions for 6G networks; and technology validation in platforms.

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; base station optimization for energy saving and network failure recovery; and the definition of an architectural framework addressing interoperability needs. As for Japan, the priorities in the scope include AI-enabled radio access network (RAN) solutions including physical layer and signal processing technologies, and open RAN/virtualization. Further details can be found in the SNS R&I Work Programme 2024.

The European private side (6G-IA) and the corresponding private sides of the target countries have played a very active role in the (down)selection of collaboration topics. The public sides, on the contrary, focused on the establishment of links with the relevant ministries/organization and the definition of call conditions.

3.2.2.4 Identification of synergies with the microelectronics sector

On the 16th of October, a dedicated workshop on micro-electronics workshop was organized in Brussels by the 6G-IA and under the auspices of the European Commission and the SNS Joint Undertaking Office. The objective was to stimulate joint/strategic cooperation, notably through structured collaboration between the Chip Act (CA) and the Smart Network and Services (SNS) Joint Undertakings. This workshop was supported by key players from both the microelectronics (e.g., AENEAS, Infineon, NXP, ST Microelectronics, IMEC, CEA, LioniX) and the communication/networking (e.g., 6G-IA, Nokia, Ericsson, CTTC; again, including a number of representatives from SNS-ICE) R&I ecosystems in Europe and, further, it counted with first-tier executives and representatives from those organizations. As a top priority for a structured R&D collaboration between the SNS and Chip Act Joint Undertaking, the following areas were identified: (i) ultra-high transmit power/system gain beyond 100 GHz; (ii) mmWave Radio integration system in a package, heterogeneous integration; (iii) high throughput capacity/fronthaul 100 Gbps digital data path; (iv) Joint Communication and Sensing; (v) new spectrum and associated challenges such as co-existence; (vi) wide-band amplifiers and integration of several frequency bands; and (vii) cost-effective III-V Si for power and low-noise amplifiers.

3.2.3 6G road-mapping in the SNS R&I Work Programme

As shown in Figure 18 below, the SNS R&I Work Programme is a (roughly) 10-year effort aimed to underpin the definition and design of future 6G systems in Europe. The programme is organized in three consecutive phases. First, several enablers, concepts and technologies will be explored (Phase 1). A detailed design and system optimization phase will follow (Phase 2). Finally, from 2026 onwards, the focus will shift on a full design of said 6G systems, and the initial exploration of technologies for next generations (Phase 3).

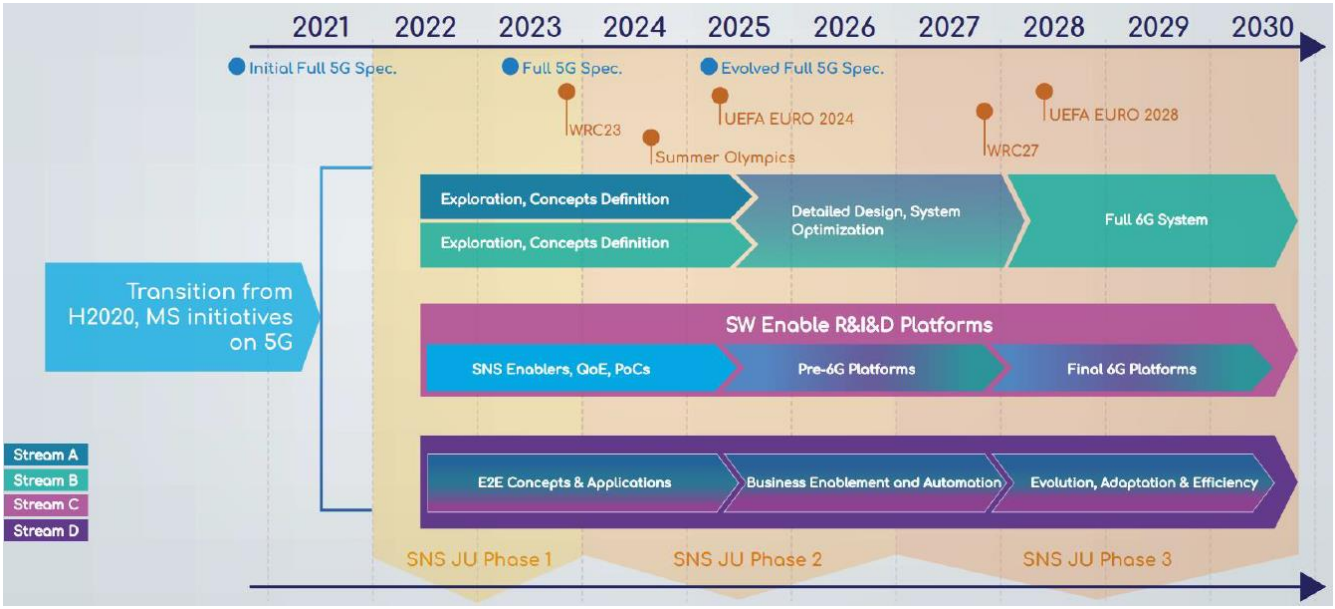

Figure 18: SNS R&I roadmap.

Internally, the SNS R&I Work Programme is organized in four distinctive streams, as shown in Figure 19. Stream A targets the development of smart communication components, systems, and networks following the evolution of 5G systems and, hence, it targets an evolutionary path to 6G (this stream was discontinued from Call 2 onwards). Stream B, on the contrary, covers research for revolutionary technology advancements, in preparation for 6G, and targets low Technology Readiness Level (TRL) technologies. Stream C focuses on SNS Enablers and Proof of Concepts (PoCs), and Stream D aims at large-scale SNS trials and pilots to explore and demonstrate technologies and advanced applications and services in vertical sectors. The interplay between Streams and Phases is illustrated via arrows in Figure 19 too. More specifically, and as explained in detail in [42],

- The 6G solutions and potential PoCs to be developed in Stream A (Phase 1 only, since the definition of 5G advanced solutions at the standards level will be over after that) and B projects, are expected to contribute to the Experimental Infrastructure projects (Stream C) and Vertical Pilot projects (Stream D) of subsequent SNS JU phases.
- Stream C experimental infrastructures are expected to serve as the basis for the subsequent phase Stream D Vertical Pilot projects.
- Experimental Infrastructure projects (Stream C) and, especially, vertical pilot projects (Stream D) are expected to provide new requirements (e.g., KVIs, KPIs) to Stream B projects of subsequent phases.

Further developments in Stream D (and also Stream C) projects are expected to follow a spiral evolutional approach, based on the successful delivery of selected past projects. Where relevant, projects are also encouraged to use results from Member States and Associated countries initiatives, in order to maximise the efficiency of public investments in Europe.

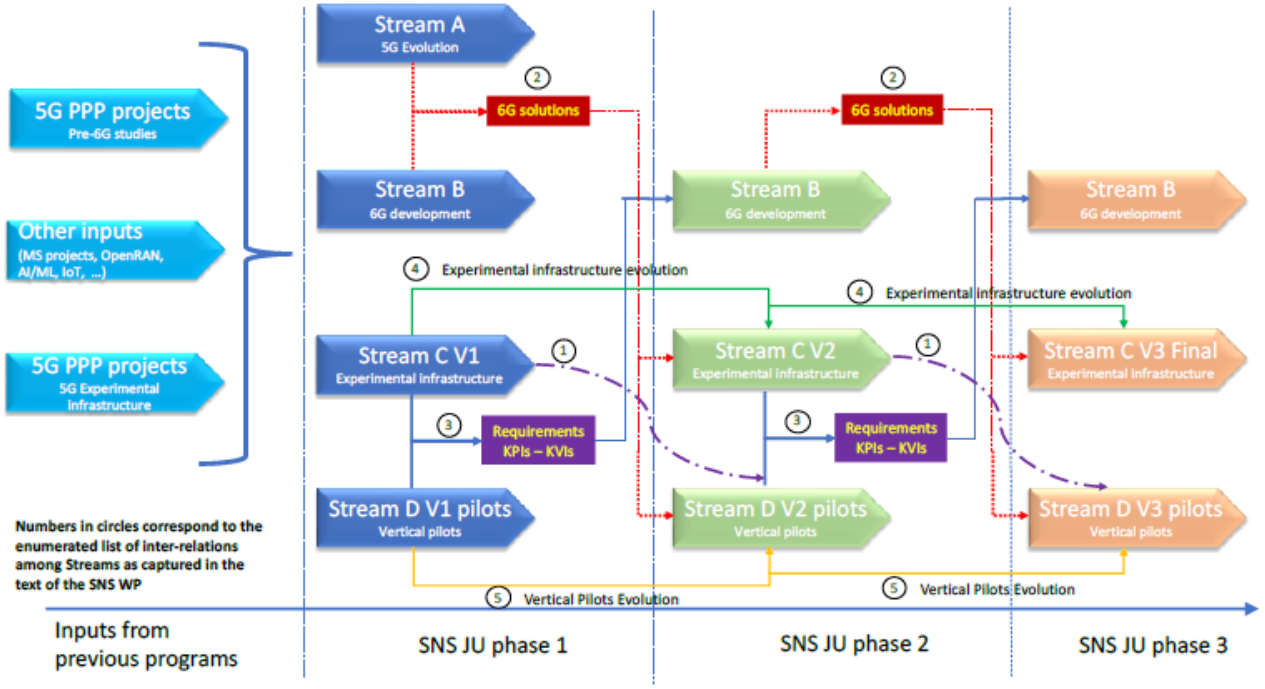

Figure 19: Phases and Streams in the SNS R&D roadmap.

3.3 Fine-tuning of SNS message and contribution to future SNS R&I WPs

This section is devoted, on one hand, to report on the approach followed to fine-tune received information from SNS projects and to create the global SNS message. On the other, it will provide suggestions and feedback to be possibly considered for the elaboration of the next versions of the SNS R&I Work Programme. Those suggestions stem from the interaction with external key stakeholders via the participation of SNS-ICE partners in international events, discussions with funding agencies from other regions, conclusions in policy-related documents such as position or white papers, and other desk research activities conducted by SNS-ICE.

3.3.1 Fine-tuning of SNS messages: initial steps

The technical work in the Call 1 SNS projects started on January 2023. Therefore, the main messages to convey in this area are mostly related to the scope, work planned to be performed by those projects, challenges being addressed and the expected outcomes. Such information was efficiently gathered by the SNS-OPS CSA (with the contribution of SNS ICE in the formulation of the questionnaire), that created and circulated a questionnaire to all 33 SNS R&I call 1 projects, as part of the SNS Monitoring & Analysis Framework (SNS OPS Deliverable D1.1[36]). The questionnaire consisted of three sections, (i) technical section (15 questions), (ii) vision section (6 questions) and (iii) market section (8 questions). All 33 projects provided their answers in the period April-May 2023. A non-exhaustive list of key insights extracted from the project answers and particularly amenable to be conveyed to an external audience includes the following aspects:

- **Projects will investigate a broad range of technology enablers**. The use of AI/ML and technologies for the orchestration VNFs/CNFs is almost ubiquitous. Other technologies include, but are not limited to, data and network autonomous management (AIaaS), cloud-native networking and RAN-core convergence, mmWave and THz radio technologies, communications and sensing co-design, deep edge-terminal-IoT device integration, integrated satellite hybrid infrastructures (NTN), blockchain, new Antenna Technologies (e.g., RIS), and digital twins.

- **The two main areas/network segments for the application of AI/ML are Radio Access Networks (RAN) and management & orchestration.** Also, a number of projects plan to use AI/ML at the device level and for security-related functionalities. Some specific examples of the use of AI include: Near-real time resource allocation, interference management, predictive scheduling, jamming detection and mitigation, network performance prediction (e.g., predicted latency), intent-based, Beam forming/tracking management, to name a few.
- **Energy efficiency aspects are mostly addressed at the network/algorithmic levels**. This includes a native/implementation of energy-efficiency aspects by design at the architecture level, on the RAN or core/management planes, on the device side, and the design of energy-conscious specific algorithms. On the contrary, the emphasis of energy efficiency at the application or connectivity service levels is much lower.
- **Priority KPIs targeted are latency, reliability and energy efficiency**. As a second priority, projects focus positioning accuracy, connection density, spectrum efficiency, data rate experienced by the user or network peak data rate.
- **Main contributions to societal challenges: acceleration of the development of advanced network infrastructures, and advanced 6G solutions for vertical industries.** Other priorities include the support to research on energy efficiency, the promotion of SME involvement, and technology sovereignty aspects across the SNS value chain.

Concerning the **methodology adopted to fine-tune messages** from SNS projects, the following considerations and remarks were considered:

- **Interfacing to and collection of information from SNS R&I projects**: This task is performed by the SNS-OPS CSA. via e.g., surveys, or direct interaction with the coordinators and technical managers in SNS-SB/TB meetings, which is chaired by the SNS-ICE Coordinator. Additional links can be established through the chairs of selected SNS or 6G-IA Working Groups or Task Forces, since some of them are SNS-ICE team members too (e.g. Trials WG, Vertical TF). Significant effort and alignment with SNS OPS was required to streamline and minimize requests, so as not to overload the SNS projects, but still be able to acquire vital and necessary information.
- **Alignment with the policies/strategies defined by the 6G-IA**: Those policies and strategies are reflected in a number of position and white papers (e.g., [41]). Such an alignment can be easily guaranteed since several SNS-ICE team members also participate in the 6G-IA Governing Board and, further, they often act as editors and/or contributors to those documents.
- **Down-selection of the messages to be conveyed**: Since the number of messages that can be effectively conveyed is necessarily limited, a consensus must be reached on the priority ones. This is mostly accomplished by the three SNS-ICE Work Package leaders, who take responsibility for the interaction with international stakeholders, national authorities and vertical sectors, respectively. To that aim, a tight coordination among them is required.
- **Decision on the SNS-ICE team member/means to convey the messages**: Owing to their professional activities and personal background, some SNS-ICE team members are more acquainted with the needs and specificities of some audiences (e.g., academia, decision makers, national authorities) or are well-known by those constituencies. Further, given their diverse nature, some messages are better conveyed via social media (e.g., LinkedIn or Twitter, for flash news); or via invited speeches, participation in panel discussions, webinars, or podcasts, for more elaborate ones. Decisions on both aspects are made in the monthly plenary meetings of the consortium, and properly reflected in the rolling dissemination plan.
- **Fine tuning of the visual identity, communication style and layout**: Last but not least, in addition to message (i.e. content) fine-tuning, aspects such as an accurate visual identity (so that the 6G-IA can easily be identified as the source for those messages), a professional layout of documents and materials, and an appropriate communication style (e.g., different stakeholders such as companies, academia, or the general audience clearly have different needs) are of utmost importance too. SNS-ICE partners 6G-IA and TRUST-IT and COMMPLA are in charge of the visual identity and the preparation of professional layouts,

all synchronised under the supervision of the Dissemination manager (Eurescom). As for the adjustments to the communication style, they are mostly in the hands of the SNS-ICE dissemination manager.

Section 4 ahead provides a detailed account of the communication actions carried out by SNS-ICE partners in the context of international events (under the responsibility of WP1). This includes the international venues where the aforementioned fine-tuned messages were disseminated. A detailed list of all the SNS ICE dissemination activities and events (not just the international ones) can be found in SNS ICE deliverable D4.2 [45].

3.3.2 Contribution to the definition of future SNS R&I Work Programmes

At the time of writing these lines, the SNS R&I Work Programme 2024 has just been launched with a deadline for the submission of project proposals by the end of April 2024. In the coming months and following to the gap analysis of the Call 1- 3 project portfolio, the definition of the Work Programme 2025-26 will begin. The global survey results and insights reported in this deliverable, regarding the relevant activities, efforts and focus of other regions of the world, will also act as input towards the Work Programme 2025-26. As an additional input, this section provides some suggestions for the consideration of the corresponding Task Force/Core Team in charge of drafting the upcoming Work Programme. They follow from the monitoring activity, observations and lessons learnt in the execution of the SNS-ICE project in its first year. More specifically,

- **Continue to fund advanced Trials and Pilots towards 6G under Stream D**: From the co-creation event on Verticals at 5G Techritory, it became apparent that the digitization of vertical infrastructure can be a powerful enabler for updated and new services, and how nowadays 5G wireless are creating economic value comparing EU with other regions in terms of GDP impact. And, also, that the level of investment in pre-commercial Trials and Pilots in other regions is far lower than in the EU. All this would allow the EU to stay one step ahead of the game and, thus, the recommendation.
- **Further boost collaboration with selected regions in the world:** To date, R&D collaborations have focused on three very relevant countries: the US, Republic of South Korea, and Japan. However, the level of funding has been limited (very few million Euro) and the level of integration low (no joint calls, mostly as standalone projects on each side running in parallel with limited interaction. The EU-US Beyond 5G / 6G roadmap elaborated in close collaboration with the NextG Alliance (see Section 3.2.2.1) calls for *"[the creation of] a concrete strategic collaboration agenda in terms of collaborative R&I actions"* and identifies al long list of areas for collaboration, which could be channelled in the upcoming releases of the SNS R&I Work Programme. Likewise, from the EU-Taiwan Joint 6G SNS Workshop in which the 6G-IA participated, and other contacts maintained, the potential collaboration with Taiwan seems to be large. This, however, deserves further analysis, given the geopolitical implications this entails. Concerning content definition, valuable insights can be obtained from the participation of SNS-ICE in international and global events (e.g., Tokyo 6G Conference, Global 5G & 6G Global Events, IEEE Future Networks World Forum among others).
- **Develop lighthouse projects considering policy priorities from the EC and key priorities in the 6G-IA Position Paper**: In the SNS R&I work programme 2024, a Lighthouse project under Stream C will be devoted to strengthening the collaboration with the microelectronics sector. This includes validation/demonstration of the performance of key 6G candidate hardware solutions, technologies, components, and architectures. In the conclusions of the micro-electronics workshop organized in Brussels (see Section 3.2.2.4), additional priorities for a structured R&D collaboration between the SNS and Chip Act Joint Undertaking were identified. The corresponding SNS and Chip Act Work Programmes could provide a vehicle for such collaborations. Same thing can be said for Photonics 21 with which a number of interactions (yet, admittedly, at a less mature level) have been maintained. Besides, upcoming SNS R&I Work programmes should also be in line with the priorities set forth in the 6G-IA Position Paper discussed in Section 3.2.2.2, namely, Cloudification/Softwarisation, AI/ML, creation of knowledge basis of experts, further advancement on sustainability and, also, microelectronics and photonics.

4 International workshops and events

4.1 Global 6G event at Techritory 2023

5G Techritory has established itself as Europe's leading 5G forum, where decision makers meet in person to discuss, network, and collaborate. It plays an indispensable role in bringing together 5G industry participants in one place to create the environment for cross-border, cross-sectoral and cross-level collaboration. The event brings together over 2000 participants and 100+ speakers from around the world.

Having its roots in Latvia, the 5G Techritory ecosystem has particular importance to the Nordic-Baltic region. The Nordic societies are among the most advanced in Europe on digitalization and all Nordic governments have ambitious strategies for the next phase of digital development. 5G technology is a key component of this work. Details regarding the organizers of 5G Techritory are provided in ***Appendix 1***.

SNS ICE partners played an instrumental role in the organization, support and promotion of the Techritory Forum 2023 event, spearheaded by VASES, that organized the entire event. The following sections provide a summary of the activities that took place in the event, as well as details regarding the SNS ICE organized sessions.

4.1.1 Overall Techritory 2023 reporting

5G Techritory, the annual 5G forum for industry participants, decision makers, and executives, was held for the 6th time on October 18-19, 2023, in person and online. While many in the 5G and telecoms space have shifted their focus to 6G – the forum insisted on maintaining its 5G focus, with this year's theme named “5G in Action”.

The forum brought together more than 140 speakers and were streamed to over 1600 registered participants globally. Over 600 leaders in telecoms, government, policymaking, ecosystem development, and more, congregated in person in Riga, Latvia, to participate as on-stage speakers as well as to contribute to a series of co-creation events.

While shifting a focus to the more buzz-worthy “6G” topic is tempting, Neils Kalnins, Director of 5G Techritory, emphasized that there is still a lot of work to be done with 5G in order to successfully build the next generation of telecommunications on top of that:

> *“Resisting the 6G hype is key to 5G growth. Yes, it's important for academics, scientists, and strategists to begin research into the next generation of telecommunications, and our event holds space for that. However, as an industry, we can't get carried away. It's imperative for us to resist the temptation to jump into the next hot topic, as there is still a lot of homework we need to do with 5G in order for emerging technologies to grow into their full potential. We need to see 5G in action first, and that is what this year's focus will be on.”* – Neils Kalnins, Director of 5G Techritory

This year's main theme was 5G in Action - exploring what the implications of 5G technologies are on our industry and society as a whole.

The topics discussed in panel discussions and workshops during the conference included on topics important to the region, such as:

- Digital transition – strengthening Europe’s technological leadership with a focus of competitiveness of the Nordic region (deployment of 5G and 6G).
- Cyber security – ensuring robust network deployments, security of networks and information systems.
- Connectivity in Europe – the state of network deployments, improvement of connectivity in rural areas.
- 5G in Defence – the use of future technologies in the defence field.
- The Metaverse – technical readiness, the impacts on various fields like Defence and Military, Healthcare, Education and how the Metaverse can help small and medium-sized businesses and start-ups grow and provide value for society.

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[13].

In addition to the on-stage program, the event was supplemented by **co-creation events and other activities to be highlighted** that were attended by over 600 industry leaders. Those included:

- An event co-hosted with the UK Department of Science, Innovation, and Technology, on the decentralization of telecommunications and cross-border collaboration.
- An event with ITU (International Telecommunication Union) placing a focus on Metaverse-related topics.
- Follow-ups on various memorandums previously signed at 5G Techritory in the hydrogen, semiconductors, and metaverse spaces.
- Hosting of Moldovan and Ukrainian Official Delegations and a roundtable on the telecoms industry's role in rebuilding Ukraine's ICT infrastructure.
- Activities for Quantum Technologies deployment in Latvia organized by Latvia State Radio and Television centre & National Quantum Initiative of Latvia. Exploring the frontier of quantum technologies, this co-creation event, featuring the collaboration between LVRTC and the National Quantum Initiative, provided a glimpse into the future of quantum communication. Quantum technology experts, scientists, representatives of the ICT industry, and policy makers signed a cooperation memorandum in the development of quantum technology.

Even more - Ukraine's Ministry of Digital Transformation signed a 10-point Memorandum of Cooperation with Latvia's Ministry of Transportation to support Ukraine in the immediate restoration of broadband internet as well as support the country's development of information and communications technology (ICT) infrastructure and its integration into EU and joint projects (Figure 20).

The memorandum was signed on the 5G Techritory stage in Riga by Ukraine's Vice Prime Minister for Innovations, Development of Education, Science and Technologies and Minister of Digital Transformation, Mykhailo Fedorov, and Latvia's Minister for Transport, Kaspars Briškens.

Figure 20: Signing of Ukraine-Latvia memorandum on ICT cooperation.

Moreover, an Agreement was signed for Deployment of Private 5G at the Riga Technical University Open RAN Laboratory. The agreement for deploying Private 5G at the Riga Technical University Open RAN Laboratory reinforced the forum's practical orientation, providing a real-world platform for testing and innovation.

One of the highlights of the event was the announcement of the Winning projects for SNS JU Second Call of Proposals. The announcement of winners for the SNS JU second call of proposals by the Executive Director of the

[13] https://www.5gtechritory.com/agenda-2023/

SNS JU Ms Erszebet Fitori, with a substantial €130 million funding boost, showcased a tangible commitment to driving innovation and research within the 5G ecosystem.

This year, more than 140 speakers took the 5G Techritory stage, covering topics from 5G in defence to OpenRAN, the metaverse, quantum computing, and more. Among them the Prime Minister of the Republic of Latvia, Ms. Evika Siliņa, the Head of OECD's Digital Economy Policy Division Ms. Audrey Plonk, the Head of Europe at Nokia Dr. Rolf Werner and more. Figure 21 depicts some of the top speakers at this year's Techritory event.

Figure 21: 5G Techritory 2023 Top Speakers – Promo material.

Figure 22: Highlights from 5G Techritory forum 2023.

In conclusion, the 5G Techritory Forum 2023 emerged as a pivotal event, showcasing not only the current state of 5G technology but also providing a glimpse into the future with discussions on 6G, the Metaverse, and quantum technologies. The collaborative spirit demonstrated through international partnerships, memorandum signings, and co-creation events solidifies the forum's position as a key player in shaping the trajectory of the telecommunications industry. Figure 22 provides some highlights from the event.

4.1.2 Overall 5G Techritory 2023 reporting

Three amazing 5G in Action-filled days, gathering policymakers, researchers, innovators, and industry leaders. Beyond question, the 6th 5G Techritory was the most action-driven Forum thus far, with two Memorandums of Understanding (Ukraine & Latvia, Quantum Technology initiative) and one agreement (deployment of Private 5G at the Riga Technical University Open RAN Laboratory) signed, huge funding announcements, speeches from Ministers, 34 panel sessions & 18 co-creation events hosted, and more. In 2023, 1687 participants were gathered (850 in-person attendees included) from 77 countries, 146 speakers, and 37 media representatives (including 27 foreign representatives). Figure 23 provides an overview of some key statistics for Techritory 2023.

Figure 23: 5G Techritory 2023 overall statistics.

4.1.3 Marketing / promotional activities carried out by 5G Techritory team

The 5G Techritory event generated more than 230 publications in local and international media – releases, opinion pieces, interviews. The event was widely covered in international media such as Forbes (USA), LeMagIT (France), Telko (Poland), EE Times (Europe), El Espanol (Spain), TelePolis (Poland), TechWar (Greece), Nyematoghelse (Norway) and many others. The event also attracted the attention of leading Latvian media, including LETA, TV3, LTV, SWH, TVNET, Delfi, Dienas Bizness, ir.lv, lsm.lv and others.

Newsletters also play a big role in promotional activities. 5G Techritory Newsletter list consists of more than 5,500 contacts. Including not only the 2023 registered attendees but also attendees from previous Forum years. Newsletter are being sent out additionally to standard/practical emails which are sent out not as newsletters but emails from registration form to registered attendees only.

In 2023 digital marketing campaigns were created in four main channels: Google (Search, Display Affinity, In-market Audience), YouTube (Video), Facebook and LinkedIn. The campaign focused on event registration, September – October, and became more active and dynamic as the conference approached.

Banner campaigns were targeted based on 5G Techritory interests (technologies, microchips, quantum technologies, innovations, 5G, AI, mixed reality, photonics, business, cooperation with state institutions,

metaverse, 6G, IoT, cybersecurity, telecommunications). The most popular (most clicks) audiences were - Technology, Network Systems & Services, Business Technology etc.

Targeted promotional material was also created and published for all the SNS organized sessions within Techritory 2023. Figure 24 depicts the promotional material used for the "Why 6G" panel, moderated by 6G-IA, SNS ICE coordinator.

A Full Marketing Report and Statistics for 5G Techritory 2023, including links to Full SNS ICE social media post report, all publications, newsletters and blog post can be found on the full SNS ICE communication activities report available on the project repository. The SNS ICE specific marketing report is provided in ***Appendix 2***, as well.

4.1.4 Overview of SNS ICE activities carried out

Within the forum, SNS ICE offered attendees the opportunity to discover the needs and requirements of different stakeholders with regards to 6G development in the 6G-IA led panel discussion "Why 6G?". Additionally, 3 co-creation events organized by the SNS ICE project, provided the chance to delve into exploring opportunities for cooperation and collaboration among the Smart Networks and Services Joint Undertaking and European national initiatives working on 6G, address sustainability challenges facing the upcoming 6G system and share experiences in developing mobile technologies, along with the results of trials to validate vertical use cases. The SNS ICE organized sessions in Techritory 2023 are summarized in Table 3.

Table 3: Overview of SNS ICE organized sessions at Techritory 2023.

Date / time	Type of activity	Title of the session	Speakers
18/10/23, 13:00 - 16:00 XG Stage	Co-creation event	National initiatives: discussion on different approaches to European collaboration for 6g research	SNS JU NI Representatives
18/10/23, 17:00 - 17:50 XG Stage	Panel discussion	Why 6G? The need for the Next Generation Smart Networks & Services and Lessons Learned from Previous Generations	Colin Willcock Raffaele de Peppe Tonko Obuljen Uwe Baeder Erzsebet Fitori
19/10/23, 9:35 - 9:55 Policy & Strategy Stage	Keynote speech	The European Path Towards 6G	Erzsebet Fitori
19/10/23, 10:00 - 13:00 Event room "Lamda"	Co-creation event	5G for sustainability, the future role of 6G	Representatives from 6G-IA, GSMA, HEXA-X-II, NOKIA, TIM
19/1/23, 14:00 - 17:00 Event room "Lamda"	Co-creation event	5G FOR VERTICALS co-creation event	Representatives from Trials WG, VITAL-5G ESA, CELLNEX, NOKIA LMT, GSMA

4.1.4.1 SNS-ICE panel

SNS-ICE partners organized and moderated one of the most interesting panels of the 5G Techritory 2023 event, entitled: "*Why 6G? The need for the Next Generation Smart Networks & Services and Lessons Learned from Previous Generations*", with the participation of key experts of diversified background as depicted in Table 4. The goal was to discuss the perspectives from different key players in the ICT ecosystem with regards to their expectations and requirements for the next generation of networks, and the points of attention based on their

expertise with 5G networks development and deployment. This panel also constituted the first appearance of the new Executive Director of the SNS-JU Erzsebet Fitori, providing the view of the EU/SNS-JU.

Table 4: Experts of the 6G-IA Panel @5G Techritory & their respective background.

Expert Name	Expert Affiliation	Background / Perspective
Colin Willcock	6G-IA Chairman of the Board, NSN (Moderator)	Vendor Perspective
Erzsébet Fitori	Executive Director SNS-JU	EU, SNS-JU
Raffaele de Peppe	6G-IA Vice-Chairman of the Board, TIM	Operator
Tonko Obuljen	President of the Council HAKOM	Regulator
Uwe Baeder	Director International Relations ITU/UN, Rohde & Schwarz	Vertical User

As the world of telecoms is accustomed to a new generation of mobile telecommunications networks – the next G – being released to the public every 10 years or so, along with promises of superior performance, new business opportunities and support of new services and applications. The 6th generation of mobile networks (6G) is set to hit the markets around 2030, with promises of going beyond just a mere telecoms networks and incorporating additional capabilities such as sensing, massive IoT and ubiquitous integration, delivering a novel suite of Smart Networks and Services (SNS). The above panel of experts, from all ends of the telecoms value chain, was assembled to discuss why do we really need 6G networks, by examining key questions from their individual perspectives:

- Do 6G networks cover a real market gap or a consumer need or is it just another hype?
- Are there applications or services that cannot be properly supported by existing networks, thus creating the need for better, more advanced connectivity or is this a case of the solution being defined before the problem exists?
- What did we learn from developing & deploying 5G networks, that should be taken into account for the development/deployment of the next generations of networks?

The experts highlighted the need for collaboration in the early stage of development, to create an inclusive technology that takes into account the needs and requirements, not just of the telecoms sectors but of the entire ecosystem. In this way, even vertical stakeholders can be included in the early phases of development, which will ensure that their needs are met. Moreover, it was stressed that besides the technical aspects, care should be given to the common developments of regulatory strategies and business cases that will facilitate the eventual deployment and roll-out of 6G networks in the real world and their adoption by the market. Finally, it was stressed by all participants that in order for the next generation of networks to be a success, a single global 6G standard should be pursued and developed with collaborative efforts with all other regions of the world.

The SNS-ICE panel was heavily promoted prior to the event itself with the publication of various promotional flyers and banners (such as the one showcased in Figure 24), over the SNS ICE and 6G-IA social media channels, as well over the media channels of the Techritory forum itself.

The session itself was heavily attended in-person by Techritory participants, filling the allocated room with a capacity of approximately 80-100 people, while it was also streamed live over the internet, where approximately an additional 70 people followed the discussion. The entire session has been recorded and is publicly available for playback[14] via the YouTube channel of the 5G Techritory forum. Figure 25 provides a few snapshots from the event.

[14] https://www.youtube.com/watch?v=Kk5aQpXJ0gs

Figure 24: SNS-ICE Panel @5G Techritory – Promo material.

Figure 25: Snapshots from the SNS ICE organized panel @5G Techritory.

4.1.4.2 National Initiatives co-creation event

During Techritory 2023, SNS ICE organized a co-creation workshop "National Initiatives: discussion on different approaches to European collaboration for 6G research". The goal of this workshop was to explore opportunities for collaboration between national initiatives working on 6G in Europe. The workshop was invitation only, with some 20 attendees from different national initiatives, SNS Office, the SNS State Representative group, SNS projects, and other organizations involved in European 6G collaboration. The workshop was a continuation of earlier SNS ICE activities to establish collaboration between different national initiatives, e.g. during EUCNC and through the establishment of an overview report of 7 large national initiatives in EU member states.

The workshop started with presentations to give different perspectives on collaboration and provide suggestions on collaboration topics. Table 5 shows the list of presenters with affiliation and title of their presentation, while Figure 26 presents the overview of the National Initiatives programmes, as presented by the SNS JU officer Chiara Mazzone.

Table 5: Presenters at the 5G Techritory co-creation workshop on European collaboration.

Talk #	Speaker	Affiliation	Title
1	Chiara Mazzone	Programme Officer, Smart Networks and Services JU	National Initiatives discussion on different approaches to European collaborati on for 6G Research - An EU-wide perspective
2	Toon Norp	SNS ICE WP2 European Collaboration	National Initiatives: Report and lessons learned
3	Paul Wijngaard	FNS program board, alliance director	6G Future Network Services (Dutch National Initiative)
4	Pekka Rantala	Head of 6G Bridge Program	FINLAND | 6G Bridge Program Perspectives
5	Xavier Priem	CELTIC-NEXT Director	CELTIC-NEXT contribution & offer
6	Kostas Trichias	6G-IA, SNS ICE Project Coordinator	SNS-ICE & National Initiatives
7	Carles Antón Haro	Member of the 6GIA Board – Chair SWG Member State Initiatives	Smaller member state initiatives

After the presentations, the workshop continued with discussions in small groups. The moderator Toon Norp (SNS ICE) provided an overview of suggestions that were given in the presentations and/or in the report on national initiatives. A vote was conducted to select three proposals out of this list which attendees wanted to discuss in the small groups, as depicted in Figure 27, in order to make these suggestions more concrete. For each of the groups, the goal was to define "*actionable recommendations*" with a clear Who, What, When (who will do what by when). The results of these discussions, and other proposals that were identified but not selected, can be found in SNS ICE Deliverable D2.1[44].

Figure 26: Slide from presentation by Chiara Mazzone (SNS Office) with overview of national initiatives.

Figure 27: Brainstorming session during the national initiatives co-creation event @5G Techritory.

4.1.4.3 5G for verticals co-creation event

It takes 10 years for a new mobile technology to become commercially available. Research, standardization, trials for validation, network deployment are needed steps to bring to market a new generation of mobile technology. 5G was not an exception. In Europe, the 5G Public-Private Partnership (5GPPP) incubated 5G, from research to trials. Then industrial players brought it to market making 5G technology the fastest mobile technology for adoption worldwide. Currently, the Smart Networks and Services Joint Undertaking (SNS-JU) is playing a similar

role in what concerns R&D activities towards the definition of 6G technologies. This co-creation event on verticals was organized 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 workshop leveraged the experience on verticals within the 6GIA on trials and engagement, real world experience on 5G deployments in specific verticals and also provided an indication of the economic impact that 5G will provide on our economies. The workshop was structured around speaker presentations and final panel discussion. The talks given by the speakers are summarized in the Table 6.

Table 6: Talks provided at the 5G for verticals Co-Creation event at Techritory 2023.

Talk #	Speaker	Affiliation	Title
1	Raffaele de Peppe, Carles Anton	6GIA Board	Welcome and introduction
2	C: Anton	CTTC	An overview of 5G -PPP pan-European T&Ps with Verticals
3	G. Landi	Nextworks	5G trials for smart assisted navigation: practical experiences from VITAL-5G project
4	M. Guta	ESA	NTN systems and technology developments in support of 5G verticals
5	S. Alina, V. Kaukomaa	Cellnex, Nokia	5G in the railway/logistics sector
6	E. Lidere	LMT	5G-enabled AR/VR for defence applications
7	P. Castells	GSMA	5G-enabled AR/VR for defence applications
8	R. de Peppe + All	TIM + All	Panel discussion: 5G for verticals: lessons learnt, challenges and what comes next
9	K. Trichias	6G IA	Wrap up/take-aways and next steps for 5G Techritory 2024

First 6G-IA members shared their experience in developing mobile technologies in selected 5G-PPP trials and pilots where a number of vertical uses cases were validated (e.g., smart navigation, remote driving, substation automation). Then several industrial players (Nokia, Cellnex, LMT) shared their experience in bringing 5G to real world in selected verticals such as logistics, railway or defence. The co-creation event also included a presentation by the Head of Economic Analysis of the GSMA on the impact of 5G in the real-world economies. In particular, this included an overview on how 5G is creating economic value comparing EU with other regions in terms of GDP impact, as depicted in Figure 28.

This type of information sparked relevant discussions during the panel, with each panellist providing their perspective on the adoption of 5G from their vertical and the relevant obstacles, lessons learnt, the challenges lying ahead, and how this process can be improved with an outlook to 6G. A snapshot of the panel is depicted in Figure 29

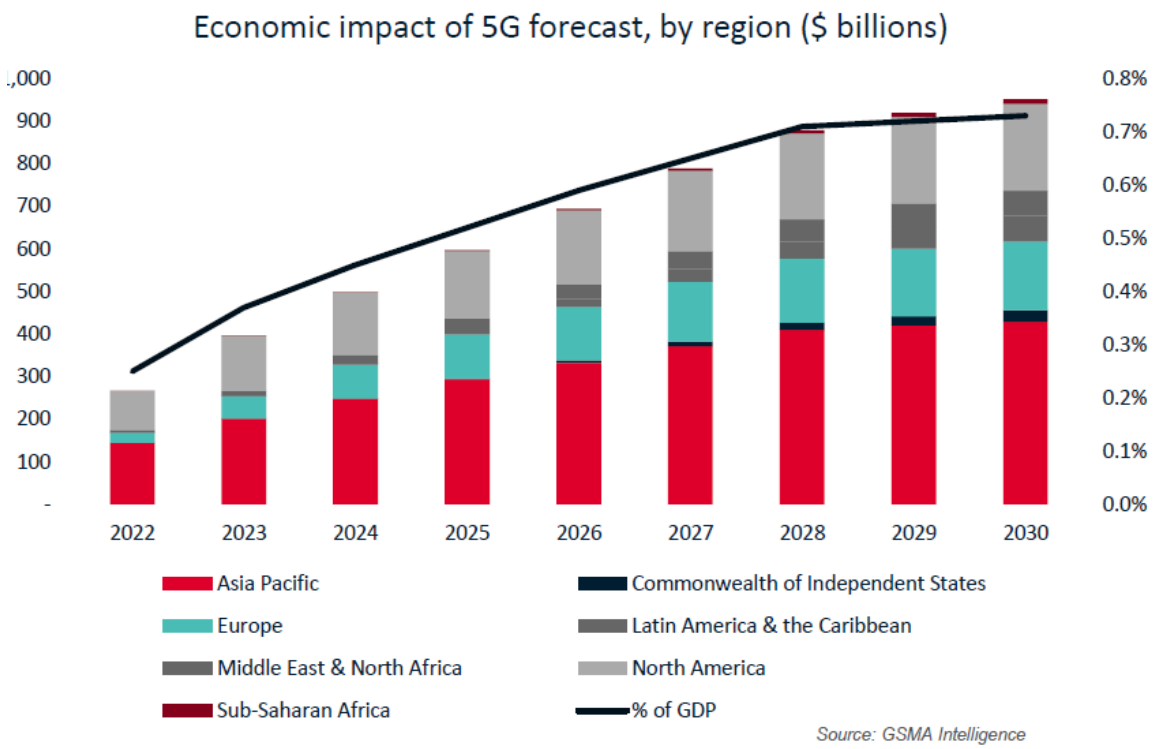

Figure 28: Economic value created by 5G comparing EU with other regions in terms of GDP impact.

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Figure 29: Panel discussion at the 5G Verticals co-creation event in 5G Techritory.

The session was concluded by the SNS ICE Coordinator, Kostas Trichias, who summarized the key takeaways from the panel discussion:

- **The digitization of vertical infrastructure and private networks can be a powerful enabler for updated and new services**. In other words, 5G has the potential to drive digital transformation in various vertical sectors, especially enterprise applications. The transport and logistics domain also offers an opportunity for significant gains in terms of man-hours and fuel efficiency. In the defence vertical, it is possible to increase safety & efficiency in multiple use cases (e.g., via AR/VR for military training).

- The **main lessons learnt** from the realization of trials and initial 5G deployments indicate that it is key to **involve verticals from the early stages of research**. By doing so, it is possible to bring together several different perspectives and get a good impression of what the performance could be like in real deployments. In addition to verticals, the **participation of the entire ecosystem** (value chain) in trials, etc. is very important too. Likewise, the business part is as important as the technical part of research projects since this leads to **better business models**.
- **Understanding the needs of the customer**, their pain points, **is crucial but it can also be challenging** when e.g., trying to build a private network. Best practices must be taken into account to optimize this process.
- As for satellite or, more generally, **Non-Terrestrial Networks (NTN), they are becoming an integral part of 6G networks**, rather than a vertical itself. In fact, NTN can cover a variety of use cases from multiple verticals. In general, **verticals are keen on using NTN communications**. The key point here is whether they are also willing to assume the extra cost this often entails.
- On the economic viability of 5G/6G networks, discussions revolved around **how the benefits on society need to be weighted when calculating the value of the technology**. In other words, how to deal with the conflict between a non-economically viable use case with great societal advantages (e.g., connected ambulance). Network financing was also regarded as a big challenge since **costs for new networks are mostly born by MNOs whereas revenues go to third parties** such as over-the-top service providers. No clear answer was found as to how to make this viable. Infrastructure deployment cost is also problematic and **update on EU regulation may assist** in the deployment of base stations.
    - Concerning specific technologies, **slicing in standalone 5G networks** is regarded as a basic enabler of differentiated services for verticals (e.g., three service layers in rail). Also, about 15% of operators claim that **IoT and private networks** is and will be a significant part of their revenue

4.1.4.4 5G for sustainability

The co-creation event about sustainability was organized in the context of Techritory 2023 and took place on October 19th, 2023. The event has been based on some invited talks and on a final round-table with the experts invited, and question & answer session with the audience, moderated by R. De Peppe, TIM. The talks given by the speakers are summarized in Table 7.

Table 7: Speakers of 5G for Sustainability Co-Creation event at Techritory 2023

Talk #	Speaker	Affiliation	Title
1	Chiara Mazzone	JU SNS	5G FOR SUSTAINABILITY, THE FUTURE ROLE OF 6G
2	Mikko Uusitalo	Nokia, Hexa-X-II coordinator	The three pillars of Hexa-X-II towards 6G: sustainability, inclusion, trustworthiness
3	Maurizio Cecchi	PIIU, Hexa-X-II	Environmental, social and economic drivers and goals for 6G
4	Mauro R. Boldi	TIM, Hexa-X-II	6G for sustainability: the enablement effect
5	Pau Castells	GSMA	Energy efficiency in the 5G (and 6G) era
6	Carlos J. Bernardos	UC3M	The WG Vision and the sustainability White Paper
7	Maria Guta	ESA	NTN and sustainability

The event has been jointly supported by SNS ICE and by the project Hexa-X-II, flagship project in JU SNS Phase 1 for the introduction of 6G in Europe. Hexa-X-II contributed with three speakers and with an active participation to the round-table at the end of the event.

A thorough discussion around the theme of the overall sustainability of the future 6G system was kept, with important insight on the possible study topics of the "Sustainable 6G" and of the "6G for sustainability", meaning all those actions of enablement that could be triggered by the introduction of 6G in other areas. Figure 30 provides a snapshot of the experts' panel during this session.

Figure 30: Co-Creation event on 6G Sustainability at Techritory 2023.

The key take-aways from the Co-Creation event are briefly summarized:

- Sustainability is a crucial topic for the future of the networks overall, and the future 6G system either will be sustainable or simply won't be.
- Speakers and panellists agreed that the usual vision on sustainability referring to energy efficiency only has to be progressed into a view where sustainability is viewed also in terms of societal impacts and economic plans.
- European Commission and specifically the Joint Undertaking SNS are supporting this view with specific actions and especially in the context of the new Work Programme 2024.
- Hexa-X-II project is leading the definition of the sustainability view towards the full inclusion in the (pre-) standardization of 6G.
- More in details, currently, Hexa-X-III is about to produce some deliverables on the topic, in the position of "flagship" project in Europe for the race towards 6G in the next years.
- Still in the context of the 6GIA and JU SNS framework a White Paper is going to be issued by the Working Group Vision.
- The enablement effects of 6G in other areas than the usual telecommunications arena are to be considered for the "6G for sustainability" approach.
- In this approach, GSMA has offered a view of the potentiality of the achievements that could be reachable.
- An example of application of sustainability in the definition of 6G has been given by ESA for the NTN field.

4.2 Other International events

Besides the SNS ICE activities in 5G Techritory 2023 as reported in the previous sections, SNS ICE partners have been very active in multiple international events during the first year of the project (2023), sometimes in collaboration with the other two CSA projects. Since its beginning in January 2023, the SNS ICE project has taken over almost all activities with regards to international event planning and attendance, except a few, that partners from the other two CSAs had already made commitments to, or there were specific reasons for another project to be in charge.

A detailed list of all the events that SNS ICE partners organized, participated in and/or facilitated during 2023, is provided in the SNS ICE Deliverable D4.2 [45]. However, 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.

- ATIS Next G ALLIANCE (US) and 6G-IA Workshop (January 2023): Following up on the 6G-IA and ATIS/NGA MoU a first virtual workshop took place to establish a dialogue between NGA and 6GIA leaders with the goal of beginning to lay out a future collaboration path. The meeting took place on 10.01.23 and was restricted to only a small number of attendees from both sides. From Europe the 6G-IA Board members the 6G-IA and 5G PPP WG Chairs, the SB and TB chairs as well a representative of DG-CNECT took place. From Europe Colin Willcock and Bernard Barani opened to workshop and Alex Kaloxylos was the moderator of the first panel entitled (Path to 6G: Roadmap, Technology, Spectrum. The second panel was entitled Parth to 6G; Sustainability, Societal Needs, Application.
- Transatlantic 6G Workshop (April 2023): On 20.04.23 the Stakeholder meeting - Input for a Transatlantic Common Vision and Roadmap for 6G took place. The meeting was organized by the EU-US trade and technology Council (TTC). From 6G-IA Dro Colin Willcock participated in panel 1 Introduction and scene setter. Hexa-X presented in Panel 2: Use case categories and technology visions.
- 6G World Summit: Taking place on 26 April 2023 in Berlin, the 6G Summit brought together global telcos, regulators, industry bodies and distinguished academia to discuss 6G business, policy and technology. It was an opportunity to connect with international 6G thought leaders and hear from telcos on their vision for 6G technology and applications. The event attracted several hundred people and from SNS-ICE, Colin Willcock represented Europe and the SNS-JU in the international panel: panel discussion titled: Building the 6G ecosystem.
- Big 5G Event: Big 5G is the leading, annual gathering for the North American executives setting their 5G and Cloud strategies for 2024 and beyond. With hard-hitting content delivered directly by the practitioners over three days and shaped by world-leading analysts from Heavy Reading and Omdia, a focused exhibition that truly allows forging connections and a series of networking activities. from SNS-ICE, Colin Willcock presented a keynote speech, “Perspectives from Europe” the talk was an Introduction to the 6G-IA organization Background and overview of the European Smart Networks and Services 6G research program Insight into future 6G plans and activities in a separate part of the conference dedicated to 6G and organized by Next G Alliance. In private discussions at this event with key persons from the Next G Alliance the next steps in the EU – US 6G research collaboration was discussed between the two industry associations.
- EU-Taiwan Joint 6G SNS Workshop: This event took place in Taipei on May 29th and attracted around 100 key experts and organization representatives from Taiwan together with several hundred participants participating remotely from Europe and Taiwan. SNS.ICE partners were instrumental in organizing the overall structure and content of this event. From SNS-ICE, Colin Willcock gave a keynote presentation of the EU 6G vision and SNS JU Roadmap. The event also included the signing of an MoU between EU-Taiwan industry association to cooperate on 6G research.
- Tokyo 6G Conference (COMNEXT): Comnext is an international exhibition where the next generation of communication technologies, including 6G, come together. The exhibition specialises in next-generation communication technologies such as 6G, private 5G, IoT, optical communications and 8K video

transmission. It is an international exhibition attracting 13625 exhibitors and visitors from all over the world. From SNS-ICE, Colin Willcock represented Europe and the SNS-JU in the international panel: Expectations for 6G initiatives in countries around the world and collaboration with Japan.

- 10th Global 5G & 6G Global Events: The global 5G event serves as a significant platform for sharing the latest trends in 5G achievements and discussing various topics related to mobile communication, global unified B5G technology standards, and industrial ecosystems. The event also covered discussions on 6G issues, in addition to 5G. Over the course of one and half days, six sessions were conducted, focusing on Regional Policies for 5G/6G, 5G Business Model and Monetization, Evolution of 5G device and solutions, 5G+6G-Evolution of 5G Network towards 6G, Future service, technology, and socio-economic trends for 6G. A total of 29 invited speakers delivered excellent presentations during these sessions. Furthermore, a special session on 5G specialized Network and applications in Korea was organized by KT, LG Electronics, and ETRI. Europe was represented by pre-recoded video presentations[15] from Peter Stuckmann, Emanuel Dotaro and Hanne-Stine Hallingby and Alex Kaloxylos with physical presence.
- Brooklyn 6G Summit: The Brooklyn Summit is widely valued in technology circles for the technical insight and global perspective it brings to the next-generation of networking. The 10th edition of the Brooklyn Summit brought together 50 speakers and panellists who were experts in their fields and leaders in their industries. The Summit also showcased more than 20 live demonstrations. The Summit welcomed 250 physical attendees from around the globe, representing vendors, academia, operators, regulators and experts from multiple industries. From SNS-ICE, Colin Willcock represented Europe and the SNS-JU in the international panel: ICT Technology Globalization, Opportunities and Risks
- IEEE Future Networks World Forum (FNWF) 2023: The SNS ICE coordinator delivered a keynote speech on the SNS JU Research and Innovation Roadmap and participated in the sub-sequent panel regarding synergies among different regions of the world. The discussion addressed common concerns and approaches from different areas of the world and focused around potential areas of improvements based on the experience on the development of previous generations.
- IEEE Int'l Conf. on Acoustics, Speech and Signal Processing (ICASSP) 2023: On June 8, Dr. Carles Antón-Haro participated in a panel discussion of R&D funding agencies at the Int'l Conference on Audio Speech and Signal Processing (IEEE ICASSP). ICASSP is the flagship conference of the IEEE Signal Processing Society. This year's edition counted with a record-breaking participation of more than 3700 in-person attendees from both academia and the industry. Dr. Antón-Haro acted as a representative of the European 6G Smart Networks and Services Joint Undertaking (SNS-JU) of which Governing Board he is an elected member. The panel on one hand was aimed at presenting funding opportunities in the area of signal processing with emphasis in international collaborations, and, on the other, at exchanging views and best practices. It counted with several program directors and high-rank officers of the National Science Foundation (NSF) and the DEVCOM Army Research Laboratory in the US, the UK Research and Innovation (UKRI) agency, the Department of Science and Technology of the Government of India, and the Ministry of Innovation, Science and Technology in Israel.
- 5th Stakeholder Workshop of the European 5G Observatory: This on-line event was held on 25 October 2023 and counted with more than 200 registered attendees, mostly from companies, regulation agencies, ministry officers, and general public. The goal was to present the main 5G market developments over the last year in Europe and the world, as well as an overview of the progress towards the connectivity targets of the Digital Decade Programme. It also counted with a panel session on the increasing need for better 5G service deployment monitoring, this including quality of service and geographical availability. In his presentation, the Trials WG Chair and member of the SNS-ICE, Carles Antón-Haro, (i) gave an overview of 5G -PPP pan-European Trials & Pilots; (ii) shared with the audience results from selected T&Ps along with additional sources of information on them (T&P brochures,

[15] http://www.5gvs.org/main.php

cartographies); (iii) outlined the plans for further Trials and Pilots to be carried out under the umbrella of SNS-JU; and, finally (iv) shared the main conclusions from the co-creation event on 5G Verticals @ 5G Techritory.

- Intelligence-Enabling Radio Communications for Seamless Inclusive Interactions (INTERACT): On May 23-25, the plenary meeting of the COST Action Intelligence-Enabling Radio Communications for Seamless Inclusive Interactions (INTERACT) was held in Barcelona. The Action aims to achieve scientific breakthroughs by introducing novel design and analysis methods for making future radio communication networks intelligent, meaning aware, adaptive and parsimonious, and contributing to the creation of intelligent environments. Its constituency includes most of the key academic players in Europe working in the field of AI/ML for 6G communications. As such, this forum is very complementary to the other more industry-related events where SNS-ICE participates. Carles Antón-Haro, as a participant in SNS-ICE and 6G-IA Governing Board member, gave a presentation on the recent 6G-IA position paper entitled 'Key Strategies for 6G Networks and Services - 6G SNS Industry Association's Vision'.
- IEEE Globecom 2023: IEEE Global Communications Conference (GLOBECOM) is one of the IEEE Communications Society's two flagship conferences dedicated to driving innovation in nearly every aspect of communications. This year over 200 engineers and experts took part in the Kuala Lumpur. The emphasis was on academic and researchers rather than industrial or regulatory participation. The SNS-ICE was actively involved with a session on 6G research in Europe. This panel, which was co-organized by the 6G-IA and the European 6G Flagship project Hexa-X-II, attempted to get a better understanding of the EU 6G research directions in terms of solutions and priorities and was moderated by Colin Willcock from SNS-ICE project. In addition, Colin Willcock was a panellist in the executive panel on TRENDS TOWARDS 6G: FROM THE WISH LIST TO THE STANDARDS. This panel involved a lively discussion among industry leaders from all world regions, looking at the future of the development of 6G, discussing the possible novelties and which of them may make the way to the standards.

4.3 Plans for future International Events

SNS ICE will remain the de facto ambassador of the SNS JU for the next period, which means creating a significant footprint especially in internationally attended events and ensuring the dissemination and promotion of SNS JU vision and achievements. The SNS ICE partners have already drafted an initial list of targeted events for 2024 which is presented in deliverable D4.2 [45]. The exact nature of SNS ICE participation and the degree of involvement (organization, presentation, attendance, facilitation, etc.) to each of these events will depend on multiple factors such as the importance/impact factor of each event, the interest an participation by the SNS Phase 1 and Phase 2 projects, the specific focus of each event and their respective audience, the potential opportunities arising, invitations for synergies on workshops, panels and sessions and more. Such factors are usually clarified as the date of each event approaches, and the opportunities will be evaluated by the SNS ICE partners.

The list of targeted events is not exhaustive, as new opportunities for other events will present themselves during the next period, through the ecosystem of SNS ICE (partners/associations with MoUs, etc.), while SNS ICE itself will lead the organization of various events (workshops, webinars, etc.) according to the SNS project needs and in coordination with the SNS Steering Board (SB). However, the presence of SNS ICE partners in certain international events in 2024, such as ***MWC 2024, EuCNC & 6G Sumit 2024, IEEE ICC 2024, IEEE WCNC 2024, 5G Techritory 2024*** and ***IEEE Globecom 2024***, can already practically be guaranteed, due to the importance and global outreach of these events. SNS ICE partners remain in constant contact with all their international and vertical partners, always seeking new opportunities to join and co-organize events, that will create synergies and further promote the ideas, results and insights of the SNS projects to the international stage.

5 Conclusions

This deliverable provides a detailed account of the activities and achieved impact of WP1 work, regarding international collaboration activities for the first year of the SNS ICE project (2023). SNS ICE is the de facto ambassador of the SNS Joint Undertaking and tasked with i) analysing the trends and reporting the B5G/6G Research and Innovation related activities of other regions of the world to the SNS stakeholders and ii) disseminating and promoting the R&I work of SNS projects to the rest of the world. This deliverable constitutes the first full report on both these activities.

A thorough analysis of the research trends in B5G and 6G networks around the world has been provided, including the *subjects and use cases of focus*, *targeted timelines, main KPIs* envisioned for future networks and *key technologies* that each region foresees as enablers of next generation networks. ***A mapping of key targeted use cases and global KPIs for seven key regions of the world*** has been performed, while an even more targeted analysis of the performance and sustainability requirements has also been delivered. In parallel, an analysis of the current ***timelines of key standardization bodies*** has been presented, highlighting their respective roadmaps and key milestones until the launch of 6G. A valuable ***report of the outcome of the WRC2023*** which will define the spectrum usage for 6G technology globally is included. Additional information has been provided regarding the planned / targeted trials and pilots in Europe, while relevant research for similar Trials around the world didn't result in significant findings, indicating that ***the EU retains a very strong position in the global R&I arena in terms of large-scale T&Ps***. Such T&Ps will assist in the development and fine-tuning of 6G technologies and will assist in the implementation of the envisioned roadmaps.

This deliverable further reports on the established communication channels of SNS ICE to interact both with the SNS JU projects as well as with the extended global SNS ICE ecosystem comprising, 6G-IA partners, global organizations, vertical associations and more. The roadmap to be followed to engage into global dialogues with key partners and to ensure that SNS JU work remains relevant and well promoted to other regions of the world is an important task of this work package. To that end, an approach to ***collect data from the projects and fine-tune key messages from the SNS JU*** to be promoted to our global partners has been presented.

Finally, an overview of all the international events that SNS ICE partners organized, participated or facilitated during the first year of the project (2023) is provided. While a detailed list of all the events that SNS ICE contributed to, is provided in deliverable D4.2 [45], this report highlights the exact contributions of SNS ICE partners to ***more than 12 major global events with significant international footprint and impact,*** within 2023. Moreover, a detailed report of the organization, promotion, attendance and gained insights from the ***5G Techritory Forum 2023*** event, which was the "crown jewel" of the SNS ICE events, with heavy participation and significant contributions from SNS ICE partners. SNS ICE organized ***3 co-creation sessions and 1 panel*** during the event, with the valuable insights and takeaways from the experts being reported in this deliverable.

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[43] Smart Networks and Services R&I Work programme 2024. https://smart-networks.europa.eu/wp-content/uploads/2023/11/sns-ri-work-programme-2024.pdf
[44] SNS ICE Deliverable D2.1 Identification of European 6G R&I stakeholders and trends, https://smart-networks.europa.eu/csa-s/#SNS-ICE
[45] SNS ICE Deliverable D4.2 Intermediate Dissemination Communication and Exploitation Report, https://smart-networks.europa.eu/csa-s/#SNS-ICE

Appendix 1: 5G Techritory Organization

5G Techritory is organized by the Electronic Communications Office of Latvia, powered by the Investment and Development Agency of Latvia (LIAA) and the European Regional Development Fund. Organized in cooperation with the International Telecommunication Union, and strategic partners Ministry of Environmental Protection and Regional Development of the Republic of Latvia, LMT, The Nordic Council of Ministers and The Nordic Council, and the Digital Accelerator of Latvia.

- **Strategic Partners:** Ministry of Environmental Protection and Regional Development, LMT, Nordic Council of Ministers
- **Silver Partners:** Freeport of Riga, British Embassy Riga, Nokia, Ministry of Defence of the Republic of Latvia, Rohde & Schwarz, Frequentis, Digital Accelerator of Latvia, Latvia State Radio and Television Centre, Latvian Council of Science, Palo Alto Networks, Ministry of Education and Science of the Republic of Latvia, VPC - Higher Education and Science Information Technology Shared Service Centre
- **Bronze Partners**: Mikrotik, Meta, Qualcomm, Red Hat, Google, Riga City Council, Tet,
- **Mobility Partner:** Rail Baltica, Co-funded by the European Union
- **Knowledge Partners:** 6G SNS OPS, 6G-IA, SNS-ICE, IS-Wireless, Magnetic Latvia, Will Townsend, Marios Nicolaou, GSOA – Global Satellite Operator's Association, Prof. Ioannis Tomkos, BroadEU.net, Public Safety Communication Europe, Latvian IT Cluster, Employers' Confederation of Latvia (LDDK)
- **Media Partners:** Delfi, LETA, Nozare.lv

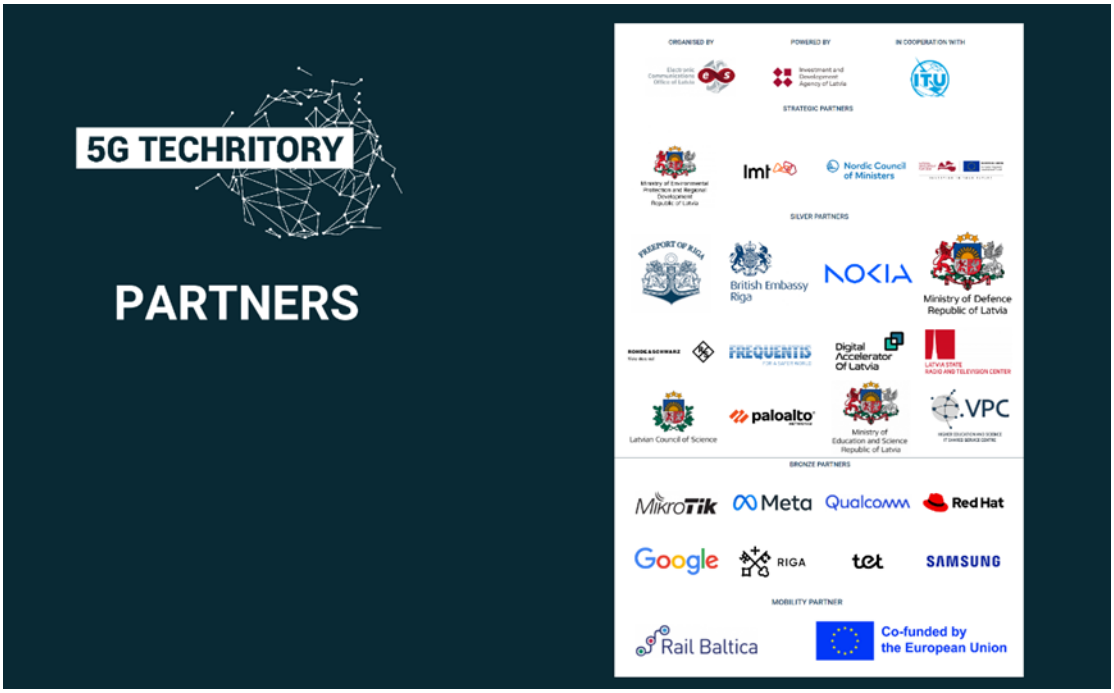


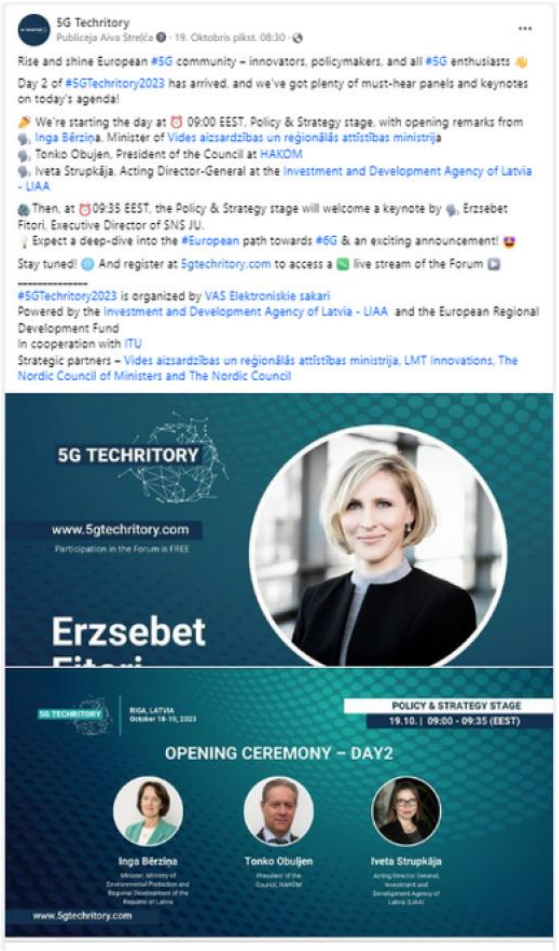
Figure 31: 5G Techritory 2023 partners.

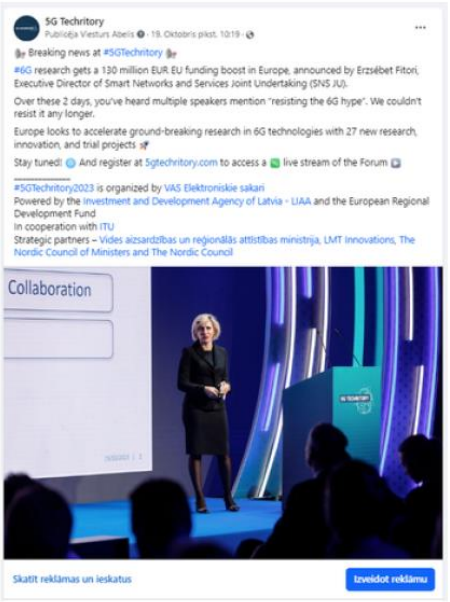
Appendix 2: SNS ICE Techritory 2023 Marketing Report

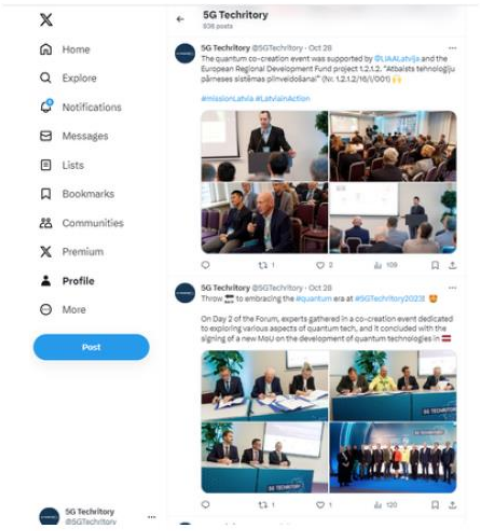
SNS ICE within Forum's communication activities

20+ social media records on Facebook, LinkedIn and Twitter

Full SNS ICE social media post report [available here]



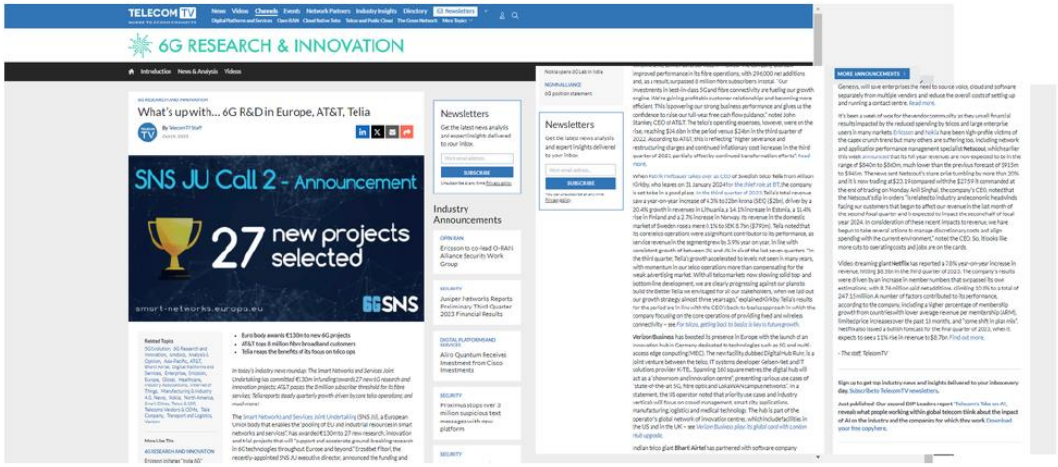


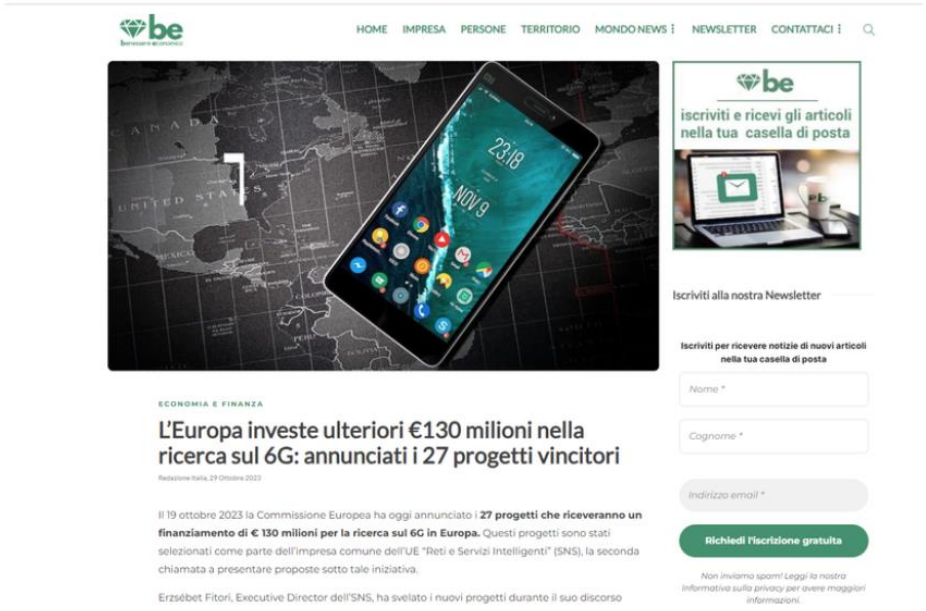


5G TECHRITORY

SNS ICE within Forum's communication activities

Mentions in media publications on international media such as: 5G.hr, Benesser Economico, Telecom TV, Monde Mobile Web, Tech war





All publications can be found in full media report: here

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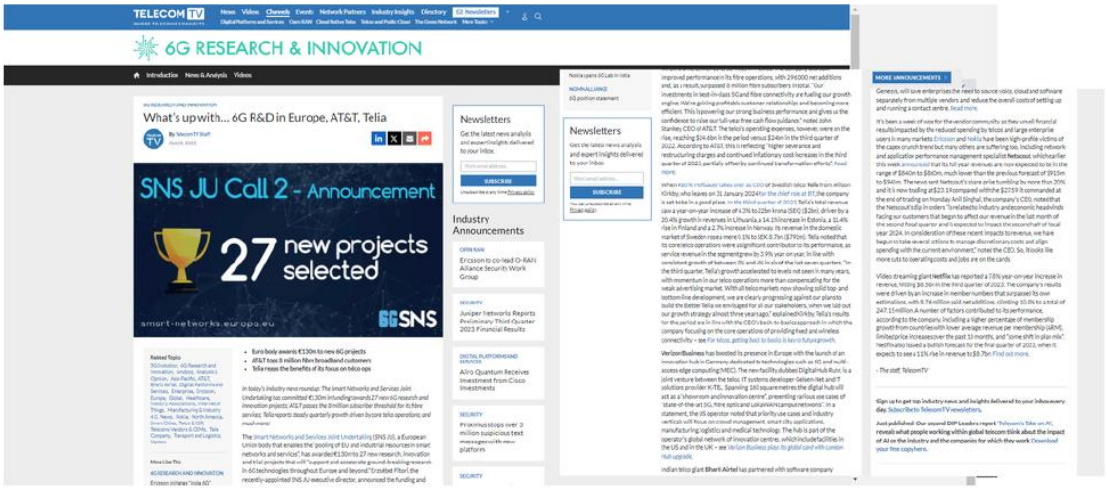

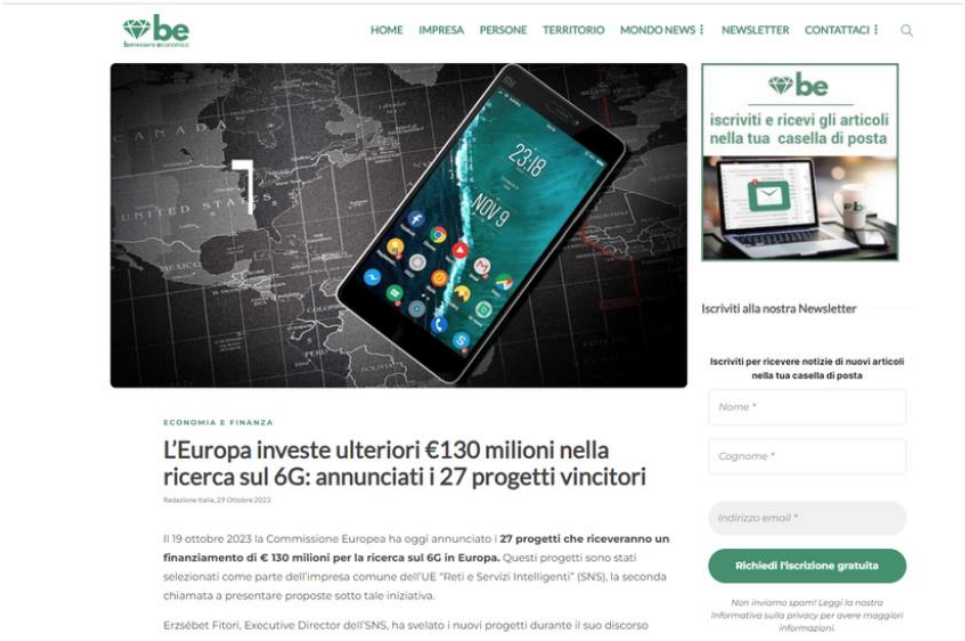

All publications can be found in full media report: here