



Smart Networks and Services International and European Cooperation Ecosystem

D2.2 Findings and Trends from European 6G R&I Initiatives

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Abbreviations List

Abbreviation / Term	Description
3GPP	3rd Generation Partnership Project
5G PPP	5G Public Private Partnership
6G-IA	6G Smart Networks and Services – Industry Association
AI	Artificial Intelligence
AI/ML	Artificial Intelligence / Machine Learning
API	Application Programming Interface
BEREC	Body of European Regulations for Electronic Communications
CaaS	Container as a Service
CAPEX	Capital Expenditure
CNF	Cloud Native Functions
CNTi	Cloud Native Telco Initiative
DG CONNECT	Directorate-General for Communications Networks, Content and Technology
ETSI	European Telecommunications Standards Institute
EU	European Union
FNS	Future Network Services
GDPR	General Data Protection Regulation
GSMA	Global System of Mobile Communications
IAFA	Impact Assessment and Facilitation Action
IPCEI CIS	Important Projects of Common European Interest in Next Generation Cloud Infrastructure and Services
ISG	Industry Specification Group
IT	Information Technology
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union Radiocommunication Sector
KV	Key Value
KVI	Key Value Indicators
LF	Linux Foundation
LFN	Linux Foundation Networking
MoU	Memorandum of Understanding
NaaS	Network as a Service
NFV	Network Function Virtualisation
NGMN	Next Generation Mobile Networks
NI	National Initiative
NTN	Non-Terrestrial Networks
R&D	Research and Development
R&D&I	Research, Development and Innovation

R&I	Research and Innovation
SME	Small & Medium Enterprise
SNS	Smart Networks and Services
SNS JU	Smart Networks and Services Joint Undertaking
SRG	State Representative Group
TRL	Technology Readiness Level
TSC	Technical Steering Committee
VNF	Virtualised Network Function
WG	Working Group

Executive Summary

This deliverable provides an overview of the SNS ICE project's activities in its second year, focusing on two topics that have been identified as important for European 6G R&I: 1) creating synergies and enhancing collaborations with European National initiatives, while also presenting the prioritization of Research aspects in the various European Union (EU) countries and 2) presenting in detail the views of the various stakeholders engaged with research relevant for the creation of a telco-cloud as proposed in the EU whitepaper "How to master Europe's digital infrastructure needs?". As SNS ICE is the ambassador of the SNS Joint Undertaking (JU) this deliverable also describes SNS ICE activities focused on collaborative efforts toward advancing 6G Research and Innovation (R&I) and bolstering Europe's global leadership in 6G.

A detailed description of SNS ICE's main activities within Europe for 2024 is provided, including the dissemination and promotion of SNS JU results, insights and vision, the leading role in the consolidation of 6G use cases from European stakeholders, the approach to analyse and stimulate collaboration with EU National Initiatives (NIs) and the alignment with other European R&I Initiatives and related associations.

Key accomplishments include:

1. **Consolidation of 6G Use Cases:** The European R&I community has developed a unified position on 6G use cases under the leadership of SNS ICE, presented at the 3GPP SA1 workshop in May 2024, enabling effective contributions to standardization efforts, and accomplishing increased impact due to the massive support from EU stakeholders.
2. **Enhanced Collaboration:** Through workshops, regular meetings, and joint initiatives, collaboration among major NIs—such as Germany's 6G Platform, Finland's 6G Flagship, and France's Acceleration Strategy—has been significantly strengthened.
3. **Cloud Innovation:** A thorough analysis of cloud initiatives highlighted vital areas for synergy, including Artificial Intelligence (AI)-native solutions, sustainability, and security.

The comprehensive National Initiatives survey presented in deliverable D2.1 has been further expanded to include the detailed profile of nine National Initiatives, representing over €2 billion in additional funding alongside SNS JU's €900 million. These programs prioritize cutting-edge 6G use cases, network architecture, and cross-domain R&I to ensure digital sovereignty, sustainability, and global competitiveness. Moreover, the analysis performed indicates a very good alignment between the NIs and the SNS JU on topics of interest, opening additional avenues of collaboration

Some key high-level recommendations, sourced from the material of this deliverable can be summarized as follows:

- **Policy and Funding Alignment:** Ensure coherence between national programs and SNS workstreams to avoid redundancies and maximize resource allocation.
- **Expansion of Collaboration Frameworks:** Regularize interaction between NIs and the SNS JU for seamless integration of national and European strategies.
- **European sovereignty in telco cloud:** to create a European eco-system of cloud/edge providers, a combination of R&I funding, standardisation and regulation is needed.

In terms of future directions, the importance of maintaining momentum in R&I, fostering industry-academia collaboration, and preparing Europe for the challenges and opportunities of a 6G-enabled future, is highlighted. The analysis performed by SNS ICE and the established network with NIs (with regular meetings between NI representatives and SNS ICE representatives) as well as the collaborative actions that are already in place, comprise an important legacy that SNS ICE will pass on to its successor CSA project.

1 Introduction

SNS ICE Work Package 2 has the task of providing information on findings and trends that are obtained through interaction with European 6G R&I initiatives and are considered relevant for the SNS community. The first deliverable of this work package, D2.1 [1], reported on European R&I initiatives both at the national and regional level. The present deliverable D2.2 is the second deliverable of the work package and focuses on topics that are most relevant for the SNS R&I community, such as cloud/3C networking, while continuing to expand the identified European R&I initiatives. The final part of this deliverable talks about the efforts taken by SNS ICE to establish dialogues at the EU level, to organize European 6G workshops and events, and to place SNS on the EU roadmap.

One of the goals of SNS ICE is to establish collaboration within Europe, both on a national level and among different European initiatives. To this end, D2.1 [1] identified and reported on seven large National 6G Initiatives within the EU member states, which each receive a funding greater than 100 M€ from their national governments. The specific initiatives identified were those in the Netherlands, Italy, Spain, Germany, France, and two in Finland. The combined research investment in these national initiatives is close to 2 Billion Euros of public funding. Comparing this with the SNS JU setting aside 900 Million Euros public funding for R&I, this makes these initiatives worth identifying and reporting on. Aside from being included in an official deliverable of the SNS ICE project, the national initiatives overview was also distributed among the State Representative Group (SRG). This overview was greatly appreciated by the SRG and subsequently other countries came forward with information about 6G research within their countries and wished to be included in the national initiatives report for the SRG. In this present deliverable D2.2, the national initiatives of two more countries, namely, Sweden and Ireland, have been included in the overview, and comparison among all identified National Initiatives is presented. Furthermore, SNS ICE initiated discussions to identify and establish synergies between the 6G National Initiatives and SNS JU, which are also reported in this deliverable.

Cloud is the second topic that was identified as of specific relevance to European 6G R&I based on the analysis in D2.1 [1]. The topic of cloud has gained even more attention after the European Commission (EC) published its white paper “How to master Europe’s digital infrastructure needs?” [2], which specifically addresses the creation of a “3C Network”, a European-wide Telco-edge/cloud. This Deliverable D2.2 provides an extensive overview, based on publicly available information, of primarily European activities that are relevant for cloud research. Additionally, this deliverable reports on a comparison between the different activities in terms of the topics they are addressing.

As the ambassador of the JU, SNS ICE devotes effort to placing the SNS on the EU road map. Within this scope, SNS ICE took on the facilitation role to gather ideas and create a consolidated vision from Europe on the 6G use cases to be presented at the standardization body, 3GPP’s workshop in May 2024. Alongside this, SNS ICE also dedicates considerable effort to organizing workshops and events to facilitate dialogues between European R&I to find synergies and foster collaboration.

The rest of the deliverable is arranged as follows: Section 2 provides an overview of the identified National Initiatives, including an abridged overview of the National Initiatives reported in D2.1 to ensure continuity for the reader. The section then goes on to address the newly identified National Initiatives, and finally presents a comparison of the research topics addressed within all National Initiatives covered so far. Section 3 of this report presents an overview of the ongoing activities within Europe on cloud and provides an analysis as well as recommendations for a way forward. Section 4 of the deliverable describes in detail all of the activities undertaken by SNS ICE to establish and promote a European view in 6G use cases. Subsequently, section 4 provides an overview of the activities that SNS ICE attended and contributed to, in order to promote the SNS JU, monitor trends across Europe, and establish collaborations and exchange information within the European R&I. Finally, Section 5 provides a summary and recommendations of this deliverable.

2 National Initiatives

2.1 Introduction

In most EU Member States there are publicly funded 5G/6G Research and Development (R&D) or trial activities. These may be EU funded through e.g., the Horizon Europe programme, Connecting Europe Facility (CEF) or European Regional Development Funds (ERDF). SNS ICE is the ambassador of the SNS JU and has undertaken the role to identify 6G initiatives in various countries and create a meaningful dialogue to foster collaboration among them and with the SNS JU, in order to ensure a unified and strong European response to 6G. Deliverable 2.1 of SNS ICE [1], identified and reported on seven large National Initiatives across Europe, namely in the Netherlands, Italy, Spain, Germany, France, and Finland. The primary criterion for picking these initiatives was that they were all funded by their national governments for large amounts (greater than 100 M€), making these large national initiatives comparable with the budget of SNS. The scope of the national initiatives overview in Deliverable 2.1 was limited to 5G/6G research and innovation funding that has a scope similar to the SNS programme. National funding for the roll out of 5G was not included.

Aside from being included in an official deliverable of the SNS ICE project, the national initiatives overview was also distributed among the State Representative Group (SRG). This overview was greatly appreciated by the SRG and subsequently other countries came forward with information about 6G research within their countries and wished to be included in the national initiatives report for the SRG. Two such countries are Sweden and Ireland. In Section 2.2 of this report, we have included an abridged version of the original overview of national initiatives from Deliverable 2.1; and a full unabridged overview of 6G research activities from Sweden and Ireland respectively has been included in the sections 2.3 and 2.4, respectively. Figure 1 shows an overview of all the national initiatives discussed in this report.

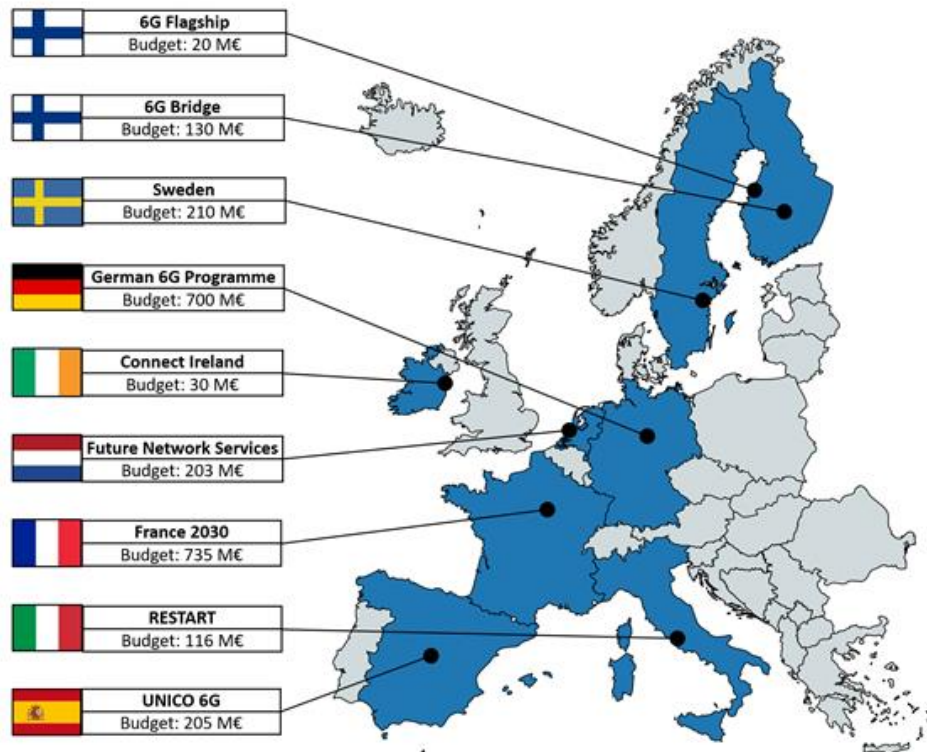


Figure 1: Overview of the 9 selected national 6G initiatives.

To facilitate comparison between activities in the national initiatives and the SNS Programme, the national initiatives report employs a categorization of activities through a list of topics inspired by the SNS work programme. Each national initiative has been asked to rate to what extent these topics are covered in their

national initiative. Section 2.5 presents a table which collates the topics and assigned star ratings of all the countries. It gives a good overview of the distribution of priorities within the different countries.

In order to identify further synergies between the national initiatives and the SNS programme, SNS ICE has organised and contributed to several activities (see section 4.6).

2.2 An abridged overview of previously reported National Initiatives

This section provides an abridged overview of the national initiatives that were also reported in SNS ICE Deliverable 2.1. This to provide background to the new sections on Sweden and Ireland, without repeating too much information.

2.2.1 The Netherlands

The Dutch national 6G programme called the Future Network Services (FNS) programme is funded through the National Growth Fund, whereby, the Dutch government will invest up to 203 M€ in FNS [3]. The programme aims to build a leading position in certain parts of 6G technology, which will strengthen the future earning power of the Dutch economy. The programme is shaped around two phases; phase 1 runs from Q1 2024 up to the end of Q2 2026 with a budget of 61 M€, while Phase 2 of the programme with 142 M€ of funding will run from Q3 2026 till Q3 2030.

In FNS, three technical programme lines are linked by a fourth programme line aimed at strengthening the ecosystem, and they are as follows:

- **Intelligent Components:** This programme line is organised in four work packages, namely, highly efficient transmitters, joint communication and sensing technology, over-the-air testing, and optical wireless communication. This programme line is mainly driven by the microelectronics industry in the Netherlands.
- **Intelligent Networks:** This programme line is organised in three work packages. The first work package focuses on requirements, architecture and integration, WP2 focuses on 6G DevOps platform and digital twin, and lastly, WP3 will work on AI-assisted networking.
- **Leading Applications:** This programme line will focus on developing application demonstrators in various market sectors, such as transport hubs, collaborative surgery, smart grid, wireless detection, 6G factory, e-commerce, and eXtended Reality (XR) gaming. These are also the verticals or key industry sectors that the programme focuses on.
- **Strengthening the Ecosystem:** This programme line will strengthen the overall 6G ecosystem through various activities, such as, setting up a national 6G testbed, technology-policy co-development, supporting start-ups and Small and Medium Enterprises (SMEs), standardization and international collaboration, etc.

FNS also works on several societal and policy aspects such as sustainability, earning power, digital autonomy (same as sovereignty) and trustworthiness. FNS will explore policy aspects such as spectrum, competition in network sharing, urban planning for 6G, etc.

2.2.2 Spain

The Spanish national initiative on 6G, called UNICO 6G R&D, is a part of the Digital Spain 2026 or the 'España Digital 2026' initiative started by the Ministry for Economic Affairs and Digital Transformation as a part of the country's digital transformation roadmap [4]. A total funding of 206 M€ is allocated to the UNICO 6G R&D programme and is distributed to the partners through the means of three open calls, one in 2021, 2022, and 2023 each.

- 2021 Call: This call led to projects being awarded to 12 entities in Nov 2021 for a total amount of 94.5 M€. The duration of the projects will be 3 years with expected Technology Readiness Levels (TRLs) between 2 and 4.
- 2022 Call: Through this call a total budget of 49 M€ was awarded to 48 projects. The duration of the projects will be up to 3 years with expected TRL of between 3 and 6 .
- 2023 Call: This call was published in December 2022 and carries an indicative budget of 62 M€. The duration of the projects will be up to 3 years with expected TRL of between 3 and 6.

The work priorities within the programme are set through the Digital Spain 2026 agenda and the implementation of the programme is overseen by the Secretariat of State for Telecommunications under the Ministry of Digital Transformation. This program carries the following goals:

- Achieve digital sovereignty for Europe;
- Support at least 200 Research, Development and Innovation (R&D&I) projects to develop the ecosystem of 5G and 6G technologies;
- Position Spain as a centre of excellence in 5G and 6G R&D.

The Spanish national initiative greatly values collaboration with the SNS. For this purpose, within the 2021 call there was an obligation imposed on the beneficiaries to contribute to the SNS JU work programme for at least 70% of the funds they have received from the national programme, after excluding the funding they have outsourced.

2.2.3 Italy

The national initiative from Italy is called RESTART: ‘RESearch and innovation on future Telecommunications systems and networks, to make Italy more smART’ [5]. The programme is planned to run from Jan 2023 to Dec 2025, with a funding of 118 M€, and comprising of a total of 25 partners.

The program includes the following activities: fundamental and applied research; technology transfer and exploitation of research results, including dissemination activities; support for the creation and development of start-ups and spin-offs from research, promoting the activities and services of incubation and venture capital funds; training led in synergy by universities and enterprises, with particular reference to SMEs, to reduce the mismatch between the skills required by enterprises and those offered by universities; PhDs program.

RESTART is organized in a Hub and Spokes structure, where the Hub is the foundation itself and it manages and coordinates the Spokes that carry out the activities to achieve the project goals. There are 8 spokes related to eight major scientific themes. The whole organization will collaborate on the implementation of 32 research projects.

- Spoke 1: Pervasive and Photonic network technologies and infrastructures
- Spoke 2: Integration of networks and services
- Spoke 3: Wireless networks and technologies
- Spoke 4: Programmable networks for future services and media
- Spoke 5: Industrial and digital transition networks
- Spoke 6: Innovative architectures and extreme environments
- Spoke 7: Green and smart environments
- Spoke 8: Intelligent and Autonomous systems

The programme focusses on 7 missions, namely, Research; Laboratories, proof of concepts, demonstrators; Innovation and Technology transfer; Support to start-ups and spin-offs; Education and training activities; PhD programs; and lastly, Communication, standardisation and open-source solutions.

In addition to the work structure described above, there are also 14 structural projects and open cascade calls. The topics for these cascade calls are decided by an international committee based on the input it receives from the various missions.

2.2.4 France

The French National Initiative is a part of the 'France 2030' recovery plan which has ecology, competitiveness and cohesion as its three main themes [6]. Launched in 2021 by the French Ministry of Economy, Finances and Industrial and Digital Sovereignty, this initiative is coordinated at national level by the Directorate-General for Enterprise/Ministry of Economy and Finance, in collaboration with other competent ministries, government agencies and the national telecoms regulatory authority (ARCEP). France 2030 has 10 objectives and 6 conditions for success which make up the plan. One of the conditions for success is to 'Master sovereign and secure digital technologies'. The French national initiative started in 2021 and is funded with 735 M€ from the General Secretariat of the Prime Minister (SGPI), managed by Direction Générale des Entreprises (DGE) of the Ministry of Economy and the Ministry of Research.

The French Acceleration Strategy on 5G & Future Network Technologies as 6G is focused on the following goals:

- Development of 5G applications and increased usage of 5G based services by the French ecosystem and society;
- acceleration of deployment of 5G vertical services;
- Supporting French companies, including SME and start-ups, working in the telecom industry;
- Strong support of R&D and standardization of future telecommunications network technologies, such as 6G;
- Joint European effort to ensure digital sovereignty;
- Development of human resources in the field of telecommunications.

The acceleration strategy is based on 4 axes:

- Axis 1: support for the development of 5G uses for the benefit of territories and industry;
- Axis 2: the development of French solutions on telecom networks;
- Axis 3: consolidation of research and development forces on future network technologies;
- Axis 4: strengthening the training offer.

Several projects along all the 4 axes have already been launched and some others will be launched soon. The French national programme also addresses sustainability issues and works on societal acceptance, cybersecurity and sovereignty concerns along with a focus on the development of human resources.

2.2.5 Finland (6G Bridge)

In Finland, there are two NIs, 6G Flagship (see section 2.2.6) and 6G Bridge. The 6G Bridge program aims to make Finland the global leader in providing new value with 5G Advanced and 6G technologies for sustainable industries and societies e.g. in smart cities, smart energy, smart ports and smart factories with different ecosystem players [7]. While the 6G Flagship is focused primarily on fundamental research, 6G bridge reduces the gaps between fundamental research and applied research. The two national programmes do not compete with each other but rather offer complementary services and insights.

The 6G Bridge offers the following program services:

- Business: innovation funding for Finnish companies for business development
- Business: innovation funding for foreign companies that are registered in Finland
- Research: funding for Finnish research organizations
- Internationalization services for Finnish companies
- Invest in Finland services for foreign companies

The 6G Bridge focuses on verticals such as health, automotive, manufacturing, energy, and receives a funding of 130 M€ for a period of 4 years from the Ministry of Economic Affairs and Employment. The work within the 6G Bridge is guided by the Finnish national Strategic Research and Innovation Agenda which defines the framework

for R&D&I activities. The 6G Bridge program encourages Finnish researchers and companies to radically increase both national and international collaboration – also outside the EU. The program goals will be met e.g. by:

- Increasing ecosystem-driven collaboration in research and innovation for 5GA/6G;
- Building future business ecosystems in 5GA/6G and attracting international investments;
- Strengthening the key capabilities in 5GA/6G;
- Fostering testing and experimentation facilities in 6G.

6G Bridge also focuses on policy and societal aspects such as sustainability and sovereignty.

2.2.6 Finland (6G Flagship)

6G Flagship is a part of the Finnish government’s national research spearhead programme from 2018 to 2026 [8]. The goal is to create the essential 6G technological components, the tools, and the equipment to build a 6G Test Network, develop chosen vertical applications for 6G to accelerate societal digitization and continue to be a recognized vision leader and sought-after research partner in worldwide 6G research. The initiative is run by the Centre for Wireless Communications (CWC) at the University of Oulu in Finland.

The programme is funded by the Research Council of Finland (RCoF) for a period of 8 years with an amount of 19.7 M€. University of Oulu contributes 16 M€ to the programme, bringing the total dedicated funding to 35 M€. However, the project operates with a total budget of 250 M€, with the rest of the funding received from faculty of ITEE and external projects, such as those funded by Horizon Europe, SNS, Business Finland, or private companies.

The programme focusses on four strategic research areas, namely, Wireless Connectivity, Devices & Circuit Technology, Distributed Intelligence, Human-centric Wireless Services. The strategic research areas are further subdivided in research themes as shown in Table 1.

Table 1: Research themes in 6G Flagship.

Strategic research areas	Research themes
Wireless connectivity	Advanced networking technologies
	Wireless access technologies
	Massive wireless automation
Devices and circuit technology	Radio platforms
	Radio hardware
	Experiments and proofs of concept
Distributed intelligence	Computing on the edge-to-cloud continuum
	Distributed AI
	Multimodal sensing and modelling
Human-centric wireless services	5GTN to 6GTN (experimentation)
	Strategic vertical areas
	Sustainability, business, and regulation

Sustainability and UN SDGs are the main driving factors in the research. The 6G Flagship has ambitions to continue its work beyond 2026 as well. There are currently discussions ongoing with the Ministry to explore options for additional funding.

2.2.7 Germany

The German 6G Programme comprises different kinds of projects. The ‘6G Platform Germany’ or more precisely the ‘Platform for Future Communication Technologies and 6G’ is the so-called ‘umbrella organization’ of the German 6G Programme [9]. It is intended both to make scientific contributions to the content design of 6G and to ensure the scientific-organizational support for the processes that are necessary for the successful

implementation of the German 6G program. The program was announced in April 2021 and is structured as follows (status September 2023):

- 2021 – 2025, 6G Platform Germany
- 2021 – 2025, Four 6G Research Hubs (depicted in Figure 2)
- 2022 – 2025, Eighteen 6G Industry Projects
- 2023 – 2025, Seven Projects on Resilience
- 2021 – 2024, AI-NET
- 2024 – 2027, Projects on high-speed networks for hyper connectivity

The 6G Programme is funded by the BMBF or the German Federal Ministry of Education and Research and the total budget of the programme was estimated to be 700 M€.

Within the German national 6G initiative, four 6G research hubs were started in 2021, with an overall budget of approximately 275 M€. These hubs are comprised of about 160 research groups at 21 universities and 15 research institutes, overall. Within the Eighteen Industry Projects, the total funding provided is approximately 150 M€; the use case scenarios and application areas which will be in focus are:

- Campus networks (automation, campus logistics),
- Medical scenarios (hospitals, emergency, operation theatre)
- Mobility (automotive, commercial vehicles, drones)
- Global coverage (satellites, rural areas, in-X networking)

The programme also focuses on several societal and policy aspects such as sustainability, sovereignty, privacy, and data protection, EM compatibility, scientific communication and gaining acceptance, trustworthiness, gender equality (women in 6G).

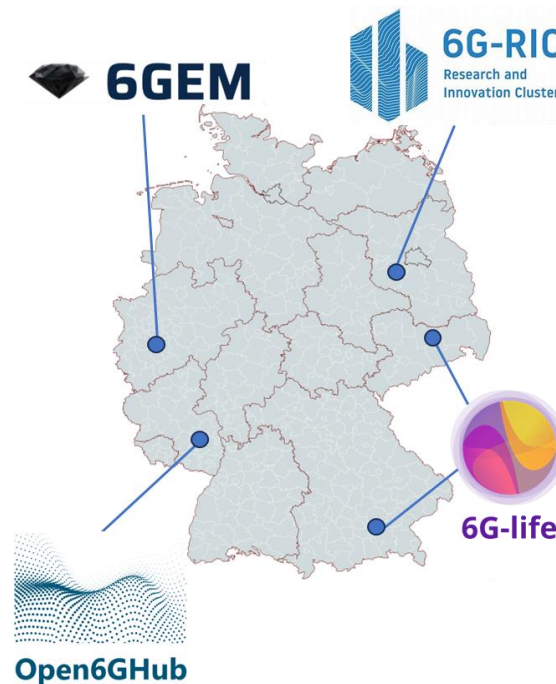


Figure 2: The four German research hubs.

2.3 Sweden

This section includes new information on 6G R&I activities in Sweden. The information was not previously included in SNS ICE Deliverables 2.1. but is provided in a similar structure and with a similar level of detail as in Deliverable 2.1. There are two different activities described; Advanced Digitisation (see section 2.3.1), and Competence Centres (see section 2.3.2).

2.3.1 Advanced Digitalisation

2.3.1.1 Introduction

The research and innovation program, Advanced Digitalisation, is formed out of a clear vision that Sweden should continue to be a leading innovation and research nation. The goal is to promote initiatives based on relevant and current challenges and thereby promote mobilization, collaboration and broad synergies. Advanced Digitization stands for a long-term partnership between industry and the state, where the state and business contribute half each. [10] [11]

Table 2: Key information on the Swedish Advanced Digitalisation

Key Information	
Responsible Ministry	Ministry of Climate and Enterprise
Total Budget	210 M€
Start Date	2023
Expected End Date	2027

2.3.1.2 Funding

The Advanced Digitalisation program has received a funding of 210 M€ from the Swedish Government for the period of 2023 to 2027. The budget and the official representation of Sweden is handled by the innovation agency, Vinnova. The program runs on a partnership basis whereby partners of the projects will at the very least match the funding provided by the government, hence bringing the total budget of Advanced Digitalization to 420 M€. The program office for this initiative is financed by the industry in addition to Vinnova.

The pre-phase of program started in 2021 and up until the end of 2023, over 400 unique organizations have participated in 180 projects. In addition to that, 12 open calls have been launched.

The program foresees funding through grants only. Funding instruments such as public procurement or loans are not foreseen.

2.3.1.3 Organisation of work

Advanced Digitalisation is a partner organization. The management structure consists of a board supported by a committee. Coordination and development of the program is managed by the program office, which can also use working groups. Preparation and documentation for project calls is handled by a program council. The board decides on working methods, overall content and strategic development. It is also about deciding on the number of program councils and the financial framework as well as any special investments.

There are four advisory committees within the program that develop recommendations to the governing board of the program, primarily on implementation of calls and other R&I activities. These advisory committees are as follows:

- Enabling technologies;
- Electrification;
- Digital infrastructure and communication;
- Learning and skills.

The program office is responsible for driving operational development with the aim that Advanced Digitization should function as efficiently as possible and ensure that the board's decisions are implemented. The program office is led by a program manager and the program work is carried out via three areas. The technology companies host the program office. The program office handles external meetings, external communications and overall promotion of the program including results.

The program council consists of experts who are experts in the field and who represent industry, the public sector, academia or industry. The assignment is to produce roadmaps, tender proposals and continuously follow the development linked to the project portfolio.

Vinnova is the agency handling budget allocation, calls, contractual agreements with participants in projects and follow-up of on-going projects. The programme aims to increase cooperation with other national programmes to strengthen synergies and to disseminate results as well as knowledge.

Partners may be added after the start of the program.

2.3.1.4 Topics covered

Using the categorization described in the introduction, the Advanced Digitalisation program is determined to cover the main topics showcased in Table 3.

Table 3: Topics covered in the Swedish Advanced Digitalisation.

Topic	Relative Importance
5G evolution R&I	**
System network architecture and Control	***
Edge and Ubiquitous computing	***
Radio technology and Signal processing	*
Optical networks	-
Network and Service security	**
Non-terrestrial networks	*
Special purpose networks/sub-networks	***
Opportunities for devices and components	*
Micro-electronics	-
Experimental infrastructure	**
Trials and pilots with verticals	***
Human capital	**
Policy aspects	*

2.3.1.5 Perspective on collaboration

Advanced Digitalisation contributes to dialogue and collaboration with the aim of spreading knowledge between projects and industries. They organize their own conferences to achieve this. The Mötesplats Advanced Digitisation (or the Meeting place Advanced Digitization) took place in 2023 and is planned again for 2025.

Advanced Digitalisation aims to collaborate with other parties through participation in calls such as Horizon Europe, SNS, etc. Partners of each center will together or individually apply for project participation in HE, SNS JU, Chips JU, EUREKA etc., and upon successful proposals have the opportunity to work together.

Standardization activities may also be a part of the projects of Advanced Digitalization.

SMEs are an important integral part of the program. One of the partners of the programme is SISP which focuses on start-ups. The goal of the organization is to develop the world's most effective innovation ecosystem by adding connectivity between its members and Sweden's leading universities, companies, public organizations, customer and exit markets. [12]

2.3.2 Competence Centers

2.3.2.1 Introduction

The Competence Centers create industry-relevant knowledge and competences. The center's collaboration between different parties leads to new knowledge in areas that the universities themselves have chosen to focus on. The knowledge must be able to be used in business or society to provide new products, processes or models. A center must also build networks and competences, so that companies have access to resources that respond to their needs. The long-term aim is to increase investments in research and development. The aim is also to strengthen research in Sweden in order to strengthen the competitiveness of other companies in Sweden. Currently there are a total of 24 competence centers; centers have started in 2017, 2020 (open to all areas) and 2023 (limited to the areas of Sustainable industry and Digital transformation). [13]

The goal of the Competence Centre program is to develop knowledge and new enabling technologies to accelerate the green and digital transition. There are 6 new 6G related R&D Competence Centres starting 2024.

Table 4: Key information on the Swedish Competence Centers.

Key Information	
Responsible Ministry	Ministry of Climate and Enterprise
Total Budget	66 M€
Start Date	2023
Expected End Date	2028

2.3.2.2 Funding

In 2023, a total of 11 new R&D Competence Centres were picked for funding through a competitive national call. Vinnova, industry partners and universities will together invest 100 M€ for the period of 2023-2028. Vinnova, the Swedish innovation agency, handled the call, and the funding decision and contracts with the centres were made after international expert evaluation.

The funding of each competence centre is divided in the following manner:

- 1/3 from the Swedish Government through Vinnova;
- 1/3 from the universities;
- 1/3 from the participating industries and SMEs.

Each 6G related Competence Centre has a budget of 9 – 16 M€ for the period of 2023 to 2028. This budget is received from Vinnova, universities, and industries plus SMEs. The grants are given out in two phases.

The Competence Centers foresee only grants as the funding instrument. No procurements or loans are foreseen.

2.3.2.3 Organisation of work

The following Competence Centers are active and focus on the listed activities:

- **NextG2Com**: This Competence Center is focused on advanced communication systems including radio-based communication and networks, as well as software, data, cyber security and applications. The center is hosted by Lund University.
The research is integrated into demonstrators and proof-of-concepts to ensure that research results are validated and implemented in practice. The partners of NextG2Com have relevant use-cases that are in-line with targets of Agenda2030.
There are 17 contractual partners in NextG2Com. Amongst them are SMEs such as Sensative, Cognibotics and Codescene. Industry partners include Volvo Cars, Ericsson, and Robert Bosch.
- **WiTech**: A Competence Center focusing on energy efficient semiconductors as well as advanced antennas and sensors to decrease environmental impact of wireless systems. The center is hosted by Chalmers University (Gothenburg).
There are 19 contractual partners in WiTech. Among them are SMEs such as Qamcom, Low Noise Factory, and Omnisys Instruments. Industry partners include Ericsson, SAAB, and Volvo Cars.
- **SEDDIT**: A Competence Center focusing on sensor information and decision-making for Digital Transformation. Climate change and security is in focus by developing autonomous systems and mathematical methods. The center is hosted by Linköping University.
There are 12 contractual partners in SEDDIT. Industry partners include Scania, SAAB, and Atlas Copco.
- **ACT**: A Competence Center focusing on advanced chip technology through new processes and methods. The research targets high-speed-electronics, opto-electronics and power electronics. The center is hosted by Lund University and KTH, Royal Institute of Technology in Stockholm.
There are 17 contractual partners in ACT. Among SMEs are NordAmps, AlixLabs and KISAB. Industry partners include Alstom Transportation, Ericsson, and Volvo Cars.
- **SweWIN Swedish Wireless Innovation Network**: A Competence Center with focus on sustainability and energy efficiency in wireless communication, and applications based on sustainable materials. The center is hosted by KTH, Royal Institute of Technology in Stockholm.
There are 8 contractual partners in SweWIN. Among SMEs are BeamWave and Northern Waves. Industry partners include Ericsson, ABB, and SAAB.
- **CoDig Continuous Digitalization**: A Competence Center with a vision of a substantial increase of enterprise competitiveness through transformation of software intensive industries to continuously deliver increased value based on next generation of data and communication infrastructure. The center is hosted by Chalmers University in Gothenburg
There are 16 contractual partners in CoDig. Industry partners include Ericsson, Grundfos, and Siemens.

Each center has a governing board which consists of the representatives of the partners. In close cooperation with the managers of each center, the governing board decides which research projects to start, proceed or close down. Each center goes through a mid-term review before decisions on additional funding are taken.

New partners may be added after the start of a Competence Center. It is also important to mention that there are Competence Centers in the program that focus on non-6G topics, such as focusing on verticals in material development and med-tech.

2.3.2.4 Topics covered

Using the categorization described in the introduction, the Competence Center program is determined to cover the main topics showcased in Table 5.

Table 5: Topics covered in the Swedish Competence Centers.

Topic	Relative Importance
5G evolution R&I	*
System network architecture and Control	***
Edge and Ubiquitous computing	**
Radio technology and Signal processing	***
Optical networks	*
Network and Service security	***
Non-terrestrial networks	*
Special purpose networks/sub-networks	***
Opportunities for devices and components	**
Micro-electronics	***
Experimental infrastructure	**
Trials and pilots with verticals	**
Human capital	***
Policy aspects	**

Sustainability is at the core of the Competence Center program and Agenda 2023 is used as a model. Human Capital, as well, is central to Competence Centers.

2.3.2.5 Perspective on collaboration

There are consortium agreements in place for each Competence Center and some centers may have international partners as well. Partners of each center will together or individually apply for project participation in Horizon Europe, SNS JU, Chips JU, EUREKA etc.

Standardization activities may be a part of the projects of the centers.

Many SMEs are contractual partners in the Competence Centers and are an important integral part of the overall program.

2.4 Ireland

This section includes new information on 6G R&I activities in Ireland. The information was not previously included in SNS ICE Deliverables 2.1. but is provided in a similar structure and with a similar level of detail as in Deliverable 2.1.

2.4.1 Introduction

CONNECT is the world leading Science Foundation Ireland Research Centre for Future Networks and Communications. CONNECT is funded under the Science Foundation Ireland Research Centres programme, which has established a network of SFI Research Centres focusing on key research areas in Ireland. CONNECT brings together world-class expertise from ten Irish academic institutes to create a one-stop-shop for telecommunications research, development and innovation. CONNECT engages with over 40 companies including large multinationals, SMEs and start-ups. [14]

Table 6: Key information on the Irish national programme.

Key Information	
Responsible Ministry	Research Ireland
Total Budget	30 M€
Start Date	2021
Expected End Date	2026

2.4.2 Funding

In order to carry out research, there is about 30 M€ in core funding available from Research Ireland to CONNECT Ireland. This funding has been allocated for a period of 6 years, starting in 2021. The programme has a target to add funding from industry collaborations, non-exchequer/non-commercial, including also in-kind contributions, which should bring the total budget to about ~75M€.

There is a specific scheme in place to promote the involvement of SMEs in the programme, whereby SMEs may choose to bring in in-kind contributions instead of cash when contributing to the budget for a project (and CONNECT adds the cash balance exchanged by in-kind).

The programme does not foresee any other funding instruments.

2.4.3 Organisation of work

CONNECT is basically structured into a set of Themes and each of them has a Working Group associated with them. The current themes are:

- **Dependable Networks**: Mission-critical innovations such as remote surgery, autonomous vehicles and Industry 4.0 will require an exceptionally high quality of service from ultra-reliable, low-latency communications networks.
- **Sustainable Internet of Things**: Energy harvesting and storage, efficient protocols and networking principles for connecting devices at the edge to the network, Highly reconfigurable software-defined devices, Resilient security mechanisms
- **Link Performance**: 5G and beyond networks will require multi-Gbps wired and wireless data transmission. In addition to increased capacity, ultra-reliable low latency links will be required.
- **AI-driven Network Customisation**: The shared network is the essential platform to build affordable customised networks where resources can be sliced and stitched together to provide an end-to-end network substrate with an allocation and configuration of resources to suit niche operators.
- **Network Ecologies**: Telecommunication networks and the research that produces them exist within, and as part of, larger social and environmental networks. Network Ecologies brings research from broad disciplinary contexts into networks research.
- **Quantum & Satellite Communications**: Quantum and satellite communications are on the cutting edge of technology, offering transformative solutions for secure and high-speed data transmission. Our research at the Connect Centre focuses on advancing the frontiers of quantum and satellite communication technologies to revolutionise how information is transmitted globally.
- **Cybersecurity**: In the realm of cybersecurity, our research theme centers on the pivotal concept of trust within network connectivity. We understand that establishing and maintaining trust is essential in an interconnected digital world.
- **Smart Cities & Connected Autonomous Vehicles**: Smart cities are at the forefront of urban innovation, harnessing technology to enhance the quality of life for their residents. Our research at the Connect Centre is dedicated to understanding the intricate dynamics that shape the evolution of smart cities and exploring innovative solutions to urban challenges.

There are two types of projects being funded at CONNECT:

- Platform projects, i.e. basic research, addressing challenges along the lines of the thematic areas as listed above. Each get a funding from CONNECT through which an Investigator can hire a post-doctoral researcher or a student, any can purchase any materials or equipment needed for the research.
- Targeted Projects, generally co-funded with an industry partner, addressing more applied research of mutual interest to CONNECT and to the industry partner. These types of projects have an agreed budget which is used to hire post-doctoral researchers or students, as well as purchase any materials and equipment needed.

CONNECT is governed through a Governance Board. Operationally, the Executive Committee makes all decisions in relation to the funding of projects, appointing new investigators etc. The projects have a minimum duration of 1 year and a maximum duration of 4 years. There are calls regularly released, averaging one call per year.

The programme offers a great deal of flexibility to allow for new topics and challenges to be introduced during the running of the programme. New industry partners may join at any time as well as acceding new academic partners from within Ireland.

2.4.4 Topics covered

Using the categorization described in the introduction, the Irish National Programme is determined to cover the main topics showcased in Table 7.

Table 7: Topics covered in the Irish National Programme.

Topic	Relative Importance
5G evolution R&I	*
System network architecture and Control	**
Edge and Ubiquitous computing	***
Radio technology and Signal processing	***
Optical networks	***
Network and Service security	***
Non-terrestrial networks	-
Special purpose networks/sub-networks	**
Opportunities for devices and components	***
Micro-electronics	***
Experimental infrastructure	***
Trials and pilots with verticals	**
Human capital	-
Policy aspects	**

Sustainability is crucial aspect of the research conducted at CONNECT, including other social aspects, which are often embedded as a part of the research for e.g. in Smart City projects. CONNECT also participates in pre-standardization and standardization activities through European Telecommunications Standards Institute (ETSI). The programme focuses on specific verticals such as Smart Cities as well as Connected Autonomous Vehicles, and to a good extent, Connect Health. The majority of the research focuses on TRL 1-4, with some projects stretching up to TRL 7.

2.4.5 Perspective on collaboration

Collaboration with other National Initiatives is often done within the scope of European funding instruments such as Horizon Europe. However, in some cases, there are specific agreements in place. One such example is the US-Ireland instrument to do cross-border research involving academics from Ireland, Northern Ireland and US.

Industry collaborations are often put in place using one Memorandum of Understanding (MoU) with all the involved partners in each project. One such MoU is the one that CONNECT has for their 6G-ONE initiative, which involves Trinity college as well as a number of industry partners such as Analog Devices, Dell, VMware, etc. Additionally, there is a legal agreement in place between all the participating universities in CONNECT, valid for the duration of the programme.

One of the barriers to collaboration with other National Initiatives on 6G is that there is no specific instrument available to foster collaborations between different countries. A great deal of benefit can be extracted if it would be possible to integrate the national initiatives into a broader platform for test, experimentation and research, and where SNS would work as a complement and an integrator.

2.5 Overview of the topics covered by the different National Initiatives

Concerning the collaboration with or among the national initiatives, it is important to identify what topics each of the national initiatives focuses on and common topics being addressed by multiple national initiatives. Based on the structured interviews with each of the national initiatives, we have summarized the relative importance of each item in a specific list of topics. Every national initiative was given the same list of topics to be scored by them, to make comparison feasible. An overview of the relative importance is presented in Table 8 below. A rating of 3-stars implies that this is a main focus area within the initiative, 2-stars is a relevant area, 1-star means 'also addressed', and zero stars means not addressed.

Table 8: An overview of topics covered by the different national initiatives.

Topic	Relative Importance									
	Netherlands	Spain	Italy	France	6G Bridge Finland	6G Flagship Finland	Germany	Sweden Advanced Digitalisation	Sweden Competence Centers	Ireland
5G evolution R&I	-	**	***	***	***	***	**	**	*	*
System network architecture and Control	***	**	***	***	***	***	***	***	***	**
Edge and Ubiquitous computing	**	**	***	***	***	***	***	***	**	***
Radio technology and Signal processing	***	**	***	***	***	***	***	*	***	***
Optical networks	-	**	***	**	-	*	***	-	*	***
Network and Service security	*	**	*	**	***	***	***	**	***	***
Non-terrestrial networks	*	**	***	***	**	*	***	*	*	-
Special purpose networks/sub-networks	*	-	***	***	***	**	***	***	***	**
Opportunities for devices and components	**	-	*	**	*	***	***	*	**	***
Micro-electronics	***	-	*	***	**	***	***	-	***	***
Experimental infrastructure	***	***	***	***	*	***	**	**	**	***
Trials and pilots with verticals	***	-	**	***	***	***	*	***	**	**
Human capital	**	*	*	**	**	-	**	**	***	-
Policy aspects	**	-	*	**	*	***	**	*	**	**

3 Cloud

3.1 Introduction

Telecommunication networks are more and more becoming ‘cloud native’, thus making European sovereignty of telco cloud very important. The European Commission addressed the creation of a telco cloud within Europe in their white paper “How to master Europe’s digital infrastructure needs?” [2], which specifically addresses the “Connected Collaborative Computing” Network (“3C Network”). Telco cloud sovereignty has also been addressed by 6G Smart Networks and Services – Industry Association (6G-IA) in their position paper “Key strategies for 6G smart networks and services” [16]. Additionally, in 6G there is a need for disaggregated 6G cloud architectures with standardized interfaces between the various stakeholders [17]. The importance of cloud is further highlighted by the organization of a workshop related to cloud and services for the SNS Work Programme (see Section 4.5.5).

In the future, it is expected that the cloud infrastructure will also provide computing services and be integrated to the telco infrastructures. However, the upcoming use of data-driven services and digital society introduces new challenges to this cloud infrastructure. Currently, it has been identified that edge computing within the EU is at its infancy and it accounts for less than 13% of the global market [2]. Therefore, there is a possible risk that the EU will depend on non-EU players for its digital transformation. Such a dependency could potentially hinder the European economy and innovation and create concerns about data security and compliance with the General Data Protection Regulation (GDPR).

Moreover, a disaggregated 6G cloud architecture is envisioned in digital societies. An important argument for such an architecture is resilience. For example, the “winner-takes-all” attitude of over-the-top players could potentially lead to scenarios where all mobile operators in a country are relying on the same 6G cloud infrastructure, which is outsourced to a hyperscaler. Therefore, any outage of the hyperscaler’s cloud infrastructure may affect all mobile network operators in the country. Moreover, the same hyperscaler could also be an attractive cloud provider for other markets, e.g., hosting smart-grids of energy providers. The hosting of different types of networks at the same hyperscaler may lead to a “chain dependency”, where an outage will affect both the mobile networks and the energy distribution networks. Additionally, an outage in the energy distribution network may affect the mobile networks.

In February 2024, the European Commission published a White Paper – “How to master Europe’s digital infrastructure needs?” [2] to identify the challenges and discuss possible solutions for a future Digital Network Act. One of the goals addressed is to create a “3C Network” within Europe, which becomes necessary as connectivity and computing are converging. To create the “3C Network”, different sectors, i.e., semiconductors, edge and cloud, radio, connectivity infrastructure, data management, and applications, need to collaborate and innovate. Moreover, the “3C Network” will ensure economic security and prosperity in Europe, increase collaboration among European players and allow European players to better compete in the global market. Moreover, it is mentioned that moving forward, research priorities could include, a.o., security solutions, interoperability, and sustainability.

Cloudification and distributed computing has also been highlighted in the Position Paper “Key strategies for 6G smart networks and services” [16] by the 6G-IA. Considering that in 6G, the applications, as well as the core and access networks will be in the cloud, cloud infrastructures become crucial. In the Position Paper, it was identified that more research is required for interoperability between cloud infrastructures. Other topics mentioned that also become important are, a.o., open-source solutions and solutions that abide to European legislation for data security and privacy.

Cloud has also been addressed by the Next Generation Mobile Networks (NGMN) Alliance in the “Cloud Native Manifesto: An Operator View” [18]. Specifically, the document addresses the application of cloud native principles in telecommunication networks by providing key principles and requirements, and a view on where the industry should put focus on.

Another important aspect is to allow the acceleration of application development and innovation, which relies on the exploitation of the network capabilities. Network capabilities are exposed via Application Programming Interfaces (APIs) and so far different developments are necessary per telecom operator. To enable application portability, i.e., applications can run on different networks, standardisation of APIs is crucial. An example of this is the new company that has been set-up by Ericsson and world leading telecom operators to allow applications work on any network [19].

Given the importance of cloud, this deliverable provides an overview and comparison of different European activities that are focusing on cloud. Specifically, multiple projects, programs, organisations and standardisation bodies are focusing on cloud. However, not all activities have the same focus and the same requirements. The overview and analysis in this deliverable aims to facilitate the better understanding of the research landscape regarding cloud and could potentially facilitate alignment between the different activities.

In Section 3.2, we provide an overview, based on publicly available information, of primarily European activities that address cloud-related topics. Even though we do not provide an exhaustive list of the ongoing activities, the selected activities cover a big range of types of activities, e.g., projects, open-source initiatives, standardisation bodies and regulatory bodies. Moreover, the overview includes a more in-depth reporting on the topics that the IPCEI CIS and the European Alliance for Industrial Data, Edge and Cloud are addressing, compared to what it was reported in Deliverable 2.1 [1]. Following the overview of ongoing activities, Section 3.3 provides an analysis and comparison of the different ongoing activities, which takes into consideration the above-mentioned needs and requirements. Specifically, the analysis addresses: focus of the activity, type of deployment, open source, infrastructure and architecture, APIs, interoperability, portability, data, orchestration and management, security, environmental sustainability, business models, policy and standardisation, and specifications. Finally, Section 3.4 concludes with recommendations and recent developments.

3.2 Ongoing Activities

3.2.1 Important Projects of Common European Interest in Next Generation Cloud Infrastructure and Services (IPCEI CIS)

Introduction

To address the new challenges of cloud and edge computing, the EU Commission approved the IPCEI CIS). The main objective of IPCEI CIS is to develop the first “Multi Provider Cloud Edge Continuum” in Europe, with focus on *interoperability, sustainability, cybersecurity and standardization* [20]. IPCEI CIS will perform R&D&I as well as first industrial deployment. IPCEI CIS, by offering a distributed, openly accessible and interoperable European cloud and edge infrastructure, is contributing to securing digital innovation within the EU. Additionally, IPCEI CIS contributes to other EU initiatives, such as Europe’s Digital Decade, the European Green Deal, the European Data Strategy and the 2030 Digital Compass [21].

After a preparation period of about three years, seven EU member states (France, Germany, Hungary, Italy, The Netherlands, Poland and Spain) have been notified for the execution of IPCEI CIS [21]. France and Germany are also acting as coordinators. Overall, there are 19 projects from 19 direct participants from the seven notified member states. Moreover, there are 90 indirect partners, who are also from an additional five member states (Belgium, Croatia, Latvia, Luxembourg and Slovenia). Overall, there are in total 120 projects that have been launched in December 2023. Participants include large, medium and small enterprises, start-ups, research organisations and Universities. Earliest IPCEI CIS projects started in Q1 2023 and will end the latest in Q4 2031. The first results are expected by the end of 2027. Note that each individual project can have its own time duration.

Topics addressed

A “Multi Provider Cloud Edge Continuum” may require to cover multiple edge locations, each located at a different distance from the devices, e.g. far edge (1-100km), near edge (100-1000km) and cloud (>1000km). Therefore, the infrastructure and the provided services should be scalable, compatible and interoperable. Moreover, the provided services will have different requirements in terms of rates, latency, energy consumption, data integrity, reliability and security. To guarantee the required Quality of Service, multiple technological advancements are needed, e.g. cutting-edge processors, highly secure chips and high-capacity storage units. IPCEI CIS will develop and deploy the infrastructure of the “Multi Provider Cloud Edge Continuum” as well as enable the migration of existing cloud capabilities to the “Multi Provider Cloud Edge Continuum”. To this end, R&D&I activities on hardware packages will be performed. Moreover, activities for infrastructure and workload management will also be performed. An example of such activity is the efficient distribution of data [22].

It is expected that new services and applications will rely more and more on the cloud-edge. This will impose new requirements in the infrastructure, e.g. interconnectivity, interoperability and service portability. Moreover, to allow users experience low latency and high data rates, data processing should be performed closed to the user location, which leads to the need of accessing the cloud-edge from different locations (also in rural areas). IPCEI CIS will perform research and implementation for network management and focusing on the telecommunication sector, IPCEI CIS will address technologies that enable multi-vendor radio access networks. Hence, mobile network operators could deploy software that run on generic hardware in a multi-vendor environment [22].

In order for applications to run on the cloud-edge continuum and fulfilling their requirements, different tools and services need to be developed, e.g. storage of high data volumes and access control. Therefore, the cloud-edge continuum should also serve as a computing environment that can be accessed by anywhere and that will offer the required application performance, as well as comply to GDPR and other protection and privacy policies. To that end, foundation and continuum control services need to be developed to, e.g. provide reliability and perform workload optimization, and to, e.g. efficiently use the resources, respectively. Moreover, a cloud-edge operating system and an API-framework are also needed. Finally, virtualization and containerized workloads are also necessary [22].

Apart from the services that provide the foundation of the cloud-edge continuum, more services are required to exploit the gains of the “Multi Provider Cloud Edge Continuum”. Specifically, platform services, data platforms and smart processing services could be addressed. Platform services could, a.o. allow developers to deploy and manage their applications and automate tasks. Data platforms will, a.o. facilitate the management of data and allow the users to manage their data. Smart processing services will, a.o. interconnect the network components and collect data for analytics [22].

IPCEI CIS will perform a first industrial deployment of the “Multi Provider Cloud Edge Continuum”, where different use cases will be validated. The deployment aims to showcase scalability, security and interoperability of services in different sectors [22].

Organisation of work

To address the above-mentioned topics and develop the “Multi Provider Cloud Edge Continuum”, IPCEI CIS organized its work in four workstreams (WS). A detailed description of each workstream, including information about the objectives, activities and focus and main contributions of each participant, is provided in [23]. Below, we provide a summary of the motivation and main goals of each workstream.

- WS1 - Cloud Edge Continuum Infrastructure: The focus is to ensure that both hardware and software are ready and allow the interconnection of networks, thus providing the infrastructure of the cloud edge continuum.

- **WS2 - Cloud Edge Capabilities:** The focus is to create a common reference architecture for constructing and operating the “Multi Provider Cloud Edge Continuum”. This could be used as guideline to deploy a cloud-edge system.
- **WS3 - Advanced Smart Data Processing Tools and Services:** The focus is to develop services that will be deployed in the cloud edge system and thus will be able to run on top of different networks and have seamless communication.
- **WS4 - Advanced Applications:** The focus is to provide use cases from different sectors that can be used to validate the implementation of the “Multi Provider Cloud Edge Continuum”.

The main contributions of each workstream are summarized in Table 9, as presented in [23]. Cross-border collaborations concerning a given workstream or cross- workstreams will also be performed.

Table 9: Main contributions per workstream in IPCEI-CIS

	WS1	WS2	WS3	WS4
Interconnection and federation	X			
Quality of Service guarantees and workload placement	X			
Open reference designs and implementations	X			
Cybersecurity	X	X		
Sustainability	X	X		
Availability/Accessibility	X	X		
Life cycle management		X		
Data and network management		X		
Workload management		X		
Data handling			X	
AI services			X	
Orchestration			X	
Information Technology/Operational Technology convergence				X
Industrial digital twins, AI integration in operational processes				X
Data ownership				X

3.2.2 European Alliance for Industrial Data, Edge, and Cloud

Introduction

The goal of the European Alliance for Industrial Data, Edge and Cloud is to secure innovation on cloud and edge technologies in the EU and to ensure that the requirements of processing sensitive data in the EU are met. The Alliance stems from the European Data Strategy [23]. In October 2020, all EU Member States have signed a declaration on building an EU cloud [24]. The Alliance was initiated by the European Commission in July 2021 and started in December 2021 with the kick-off event hosted by the European Commission [25]. As of July 2024, there are 56 members and there is an open application to join the alliance at any time. Private and public organizations can join the Alliance, assuming that they meet the eligibility criteria presented in [26].

Topics addressed

The European Alliance for Industrial Data, Edge and Cloud aims to provide [27]:

- A platform where investment synergies on cloud and edge technologies can be leveraged.
- Recommendations and a platform on EU investments for businesses and public authorities.
- A platform where the European Commission and the EU Member States can coordinate on public procurement and usage of cloud.

- Consultation and expertise to the European Commission regarding the EU Cloud Rulebook, common standards and requirements.
- Create synergies with Common European Data spaces, especially on highly sensitive personal, public sector and business data, which may also require high security.

In July 2023, the European Alliance for Industrial Data, Edge and Cloud published the “European Industrial Technology Roadmap for the Next-Generation Cloud-Edge”, providing insights on which technologies are important for investment [28]. The roadmap is addressing different domains, i.e., the EU edge cloud computing landscape, digital sovereignty, three traversal domains (energy efficiency, cybersecurity and interoperability), computing and networking infrastructure and sector-specific services. For each domain, recommendations are derived for short-, mid- and long-term. A digital copy of the roadmap is available in [28].

Moreover, focusing on the telecommunications industry, the “Telco Cloud Thematic Roadmap” has been delivered to the European Commission in June 2024. The roadmap includes various requirements based on the telco and edge application use cases and highlights aspects like cybersecurity, trustworthiness, autonomy and digital sovereignty. Moreover, a presentation of ongoing initiatives is provided, as well as an analysis on gaps and challenges in various technological domains. The roadmap is concluded with a set of recommendations. A digital copy of the roadmap is available in [29].

Organisation of work

Within the Alliance, multiple Working Groups (WGs) on different topics are in operation. Each WG elects a Chair and Vice Chair(s). The WGs are [26]:

- The Cloud - Edge WG provides and keeps updating a strategic roadmap related to cloud and edge technologies. As part of this WG, the roadmap for the next-generation cloud-edge and the thematic roadmap on “Telco Cloud” as a challenge for next-generation edge and cloud have been delivered.
- A WG responsible for the investments for developing and deploying cloud and edge technologies within Europe.
- A WG for advising the European Commission on the EU Cloud Rulebook.
- A WG on public procurement of cloud services, where only public authorities of the Member States can participate.
- A WG specifically on cloud for defence and security, which are sectors that require high security.

3.2.3 Gaia-X

Introduction

Gaia-X enables a federated and secure data infrastructure, whereby data are shared, with users retaining control over their data access and usage. It enables the creation of links between many cloud service providers in a wider, transparent and fair ecosystem to drive the European Data economy of tomorrow [30].

Gaia-X is a non-profit association in which its members (more than 300) define the Gaia-X architecture & rules. Gaia-X makes and supports others to make open-source implementations of its specifications.

A board of Directors representing 24 large European companies is driving the management board which is managing Policy rules, Data&Services business and technical committees.

Topics addressed

Gaia-X Ecosystems support the creation and development of Data Spaces and projects. Data Space creation and delivery is one of the core elements that Gaia-X tries to realise in a single or multiple ecosystems. i.e. Health, Infrastructure, Tourism and more, which could potentially multiply the overall business impact and replicate the delivery of additional data spaces in a snowball effect in as many vertical ecosystems as possible.

Gaia-X aims to connect the Data and Infrastructure Ecosystems and relies on 3 conceptual pillars to achieve that [31]:

- Gaia-X Compliance: Decentralized services to enable objective and measurable trust
- Data Spaces / Federations: Interoperable & portable (Cross-) Sector data-sets and services
- Data Exchange: Anchored contract rules for access and data usage

In concrete terms, for each of these pillars there are 3 types of deliverables: Functional specifications, Technical Specifications and Software.

Organisation of Work

The Gaia-X European Association for Data and Cloud Association Internationale Sans But Lucratif (AISBL) is composed of four main bodies [32]:

- The Board of Directors, the decision-making body of the organization, elected by the General Assembly for two-year terms. Only people from organizations with worldwide headquarters in Europe may be elected to the Board.
- The Policy Rules Committee, appointed by the Board of Directors. The Policy Rules Committee defines the Policy Rules Document, which lays out rules to be fulfilled by members and services declared within Gaia-X to reflect the "European Values" of Gaia-X (Transparency, Data Protection, Portability, Security).
- The Technical Committee, chaired by the Chief Technical Officer, which defines the
 - mandatory Functional specifications;
 - mandatory Technical specifications;
 - mandatory Compliance specifications, being translated from the Policy Rules Committee; and
 - optional specifications for a reference implementation.
- The Data Space Business Committee, which supports the creation of data spaces around requirements of users of cloud services in vertical markets: Financial Services, Healthcare, Manufacturing, Space, Energy, etc.

3.2.4 Global System for Mobile Communications (GSMA)

Introduction

The GSMA is a leading organisation representing the interests of mobile network operators globally, driving innovation and setting standards within the mobile communications industry. Two of its most prominent initiatives are the Open Gateway Initiative and the Operator Platform Group, both of which are designed to enhance the capabilities of mobile networks and foster growth in the broader digital ecosystem. The Open Gateway Initiative was launched to develop a set of standardised APIs that allow developers, businesses, and enterprises to access key network functions such as network slicing, quality of service, and enhanced security features. These APIs are designed to work across different networks to ensure a consistent user experience. Meanwhile, the Operator Platform Group focuses on creating a unified, federated platform for edge computing services, enabling mobile network operators to provide low-latency computing resources to businesses. Key members of these initiatives include major global telecom operators such as Vodafone, AT&T, and Deutsche Telekom, as well as technology partners like Microsoft and Google. Major milestones include API standardisation efforts and trials, with broader deployments expected by 2024. [33]

Topics addressed

The Open Gateway Initiative addresses several critical challenges that have traditionally hindered the integration of telecom networks with digital services. One key goal is to standardise access to network capabilities, such as traffic management, quality of service, and security protocols, through a set of open APIs. These APIs enable developers to build applications that leverage network intelligence without requiring deep technical knowledge of telecom infrastructure. Topics such as 5G technology, Internet of Things applications, and the integration of

Augmented and Virtual Reality services are central to this initiative. In contrast, the Operator Platform Group focuses on edge computing, which is essential for low-latency applications like autonomous vehicles, smart cities, and real-time analytics. The group is working on enabling operators to leverage edge nodes, bringing computing resources closer to the end user and enhancing service performance. [34]

Organisation of Work

The Open Gateway Initiative and the Operator Platform Group are organised through collaborative working groups that involve a wide range of stakeholders from across the telecommunications and technology sectors. In the Open Gateway Initiative, working groups are tasked with developing APIs that are scalable, secure, and interoperable across different operator networks. These groups include engineers, developers, and industry experts from member companies who collaborate through regular workshops and technical meetings. GSMA provides coordination and oversight to ensure alignment with industry standards [35]. Similarly, the Operator Platform Group organises specialised teams focused on edge computing architecture, creating a marketplace for these services, and establishing federations between operators. Updates and findings are shared within the GSMA community and with external stakeholders such as cloud providers and regulators [36]. Both initiatives follow defined roadmaps with milestones, and feedback from early trials is integrated to refine the solutions.

3.2.5 Cloud Native Telecom Initiative (CNTi)

Introduction

Since 22 July 2024, The Cloud Native Telco Initiative (CNTi) has become an official project under Linux Foundation Networking (LNF). CNTi is a ground-breaking open-source community project accelerating the adoption of Cloud Native technology suitable for telecom networking [37]. The initiative meets the needs of both vendors and service providers through the creation of a conformance program unifying cloud native goals and collaborating with other telco communities to foster common guidelines. The evolution of CNTi from an initiative to a project within LFN not only solidifies CNTi's mission but also amplifies our collective efforts towards building a future-proof, cloud-native ecosystem for the telco industry. Benefits of being an official project include increased visibility, more collaboration, and additional resources and infrastructure.

CNTi was conceived with a clear vision: to accelerate the adoption of cloud native technologies within the telecommunications sector. As telcos worldwide face increasing demands for scalability, agility, and cost-efficiency, the transition to cloud-native architectures has become imperative. Born from existing cloud native telco efforts from both LFN and CNCF, CNTi became a unified initiative at the end of 2023 and has continued to grow in developing needed guidelines and tools for the Cloud Native Network transformation.

Topics addressed

Currently, the community is focusing on building out three key areas:

- **Best Practices [38]:**
The CNTi Best Practices focus area operates under the aegis of LFN. The scope of this focus area is to define cloud native networking best practices. The group collaborates with the CNTi Test Catalog and CNTi Certification focus areas who work on the implementation and mechanics of the test catalog and the definition of cloud native certifications.
- **Test Catalog [39]:**
The CNTi Test Catalog is a tool that validates telco application's adherence to cloud native principles and best practices. This Test Catalog focus area works closely with the CNTi Best Practices and CNTi Certification focus areas.

The test suite is an open-source test suite for Cloud Native Function (CNF) developers and network operators to evaluate how well a network application, aka Cloud Native Network Function, follows cloud native principles and best practices.

- Certification [40]:

The CNTi Certification program provides a way for open and closed source network functions (i.e. applications providing networking functionality) to demonstrate their adoption of cloud native best practices with the help of an open source testing framework called the CNTi Test Catalog. At the moment of writing this report, the certification is in Beta stage.

Organisation of Work

The CNTi is an opensource project under the Linux Foundation (LF), it follows the regular charter of LF projects.

The technical Steering Committee (TSC) is responsible for all technical oversight of the open-source project. The TSC voting members are comprised of select representatives from participating companies. At the inception of the project, TSC voting members are appointed by participating companies. TSC projects are involving Contributors (anyone in the technical community that contributes code, documentation, or other technical artifacts to the projects) and Committers (contributors who have earned the ability to modify source code, documentation or other technical artifacts in a project repository). The TSC may establish work flow procedures for the submission, approval, and closure/archiving of sub-projects. The TSC may elect a chair who will preside over meetings and TSC and serve as the primary communication contact between the project and LFN.

3.2.6 Anuket

Introduction to Anuket

Anuket is an open-source project under LFN, which was created by merging the Cloud iNfrastructure Telco Taskforce (CNTT) and Open Platform for Network Functions Virtualization (OPNFV). Its mission is to provide reference infrastructure models, standardized architectures, and conformance frameworks to enable cloud-native and Virtualized Network Functions (VNFs). The project helps telecom operators reduce costs and accelerate the deployment of 5G and other next-generation services by ensuring compatibility and efficiency across multi-vendor environments. Major players, including AT&T, Orange, Huawei, and Vodafone, are key contributors. The most recent release is Moselle [41].

Topics addressed

Anuket addresses several critical issues in the telecommunications industry's transition to cloud-native infrastructures, with a primary focus on automation, orchestration, and security—all of which are crucial for the deployment of 5G networks. A key goal of Anuket is to create interoperability between different vendors' solutions, ensuring that they can work seamlessly across multiple cloud environments. This standardization reduces fragmentation in telco cloud development, which has historically been a challenge as telecom operators adopt virtualised and cloud-native technologies.

- One of the central topics Anuket focuses on is *edge computing*, a foundational technology that brings computing power closer to the end user to reduce latency, particularly for services that rely on real-time processing such as smart cities, autonomous vehicles, and industrial Internet of Things applications. By developing common models and frameworks for infrastructure automation, Anuket allows operators to efficiently deploy and manage network functions at the edge. [42]
- *Network fabric programmability* is another key area where Anuket is pushing advancements. This involves making the underlying network infrastructure dynamically configurable through APIs and

software-defined mechanisms, enabling more efficient traffic management and optimized use of network resources. By standardizing these functions, Anuket helps reduce operational complexity for telecom operators while improving service agility and scalability. [43]

- Moreover, Anuket's work directly supports the deployment of 5G by ensuring that the infrastructure is robust enough to handle the demands of VNFs and cloud-native network functions (CNFs). These efforts are vital in enabling next-generation telecom services, much like how the GSMA's initiatives are enhancing network service capabilities through standardized APIs and infrastructure frameworks. [44]

Organisation of Work

Anuket is organized into several working groups, each tasked with developing reference models, compliance tools, and testing frameworks. The project's Technical Steering Committee guides the development, with leaders from telecom giants like AT&T and Telstra overseeing progress. Collaboration between vendors and operators ensures that standards are tested and implemented in real-world environments, streamlining the deployment of telecom services. Regular updates, such as the Kali release, help align Anuket's goals with industry needs, providing tools for automated testing, network observability, and infrastructure security.

3.2.7 Sylva

Introduction

Project Sylva is an open-source project under the Linux Foundation Europe. The project Sylva was formed by five European operators (Telefonica, Telecom Italia, Orange, Vodafone and Deutsche Telecom) and two vendors (Ericsson and Nokia) under an MoU and Sylva was launched in November 2022. Even though Sylva is driven by the European telecom needs, it is not limited to EU participants [45]. Project Sylva specifically addresses Telco (e.g. 5G, OpenRAN) and Edge use cases and its main goal is to provide a cloud software framework, develop a reference implementation and create a validation program. The developed framework will enable network function vendors to demonstrate their functionalities on a general-purpose infrastructure and promote digital innovation. The first version of the cloud stack, named Sylva V1, has been released in February 2024. [46]

Sylva is also based on and contributes to the telco ecosystem. For example, the network performance requirements considered at Sylva are based on the work of Anuket and OpenRAN. Moreover, testing at Sylva is based on the testing framework from Anuket, which will then be enhanced based on the feedback from the Sylva project. Additionally, Sylva is compliant with the Anuket reference architecture. The Sylva project, also has synergies with the O-RAN ALLIANCE, Gaia-X, ETSI, ENISA and other initiatives and projects. [47]

Topics addressed

Cloud Native Infrastructures enable applications to run on top of Container as a Service (CaaS), which run on any type of commercial hardware. In the Telco sector, cloud native infrastructure can be exploited by running, e.g., 5G core Network Functions and Radio Access Network functions, on a CaaS. Currently, there is fragmentation for developing applications, as some applications require a specific CaaS and compute capabilities. This creates complexity for the network function vendors, who need to ensure that their Network Functions are behaving correctly on top of different platforms (in different clouds), as well as for the operators, who need to manage Network Functions from multiple vendors that need to run on different infrastructures. Moreover, this fragmentation can lead to wasted compute power, and hence Capital Expenditure (CAPEX) and energy. Project Sylva address the above-mentioned problem and aims to provide a CaaS catered to the Telco sector, as shown in Figure 3, which considers the EU requirements on cybersecurity, trustworthiness on processing of data, federation of services and energy management. [48]

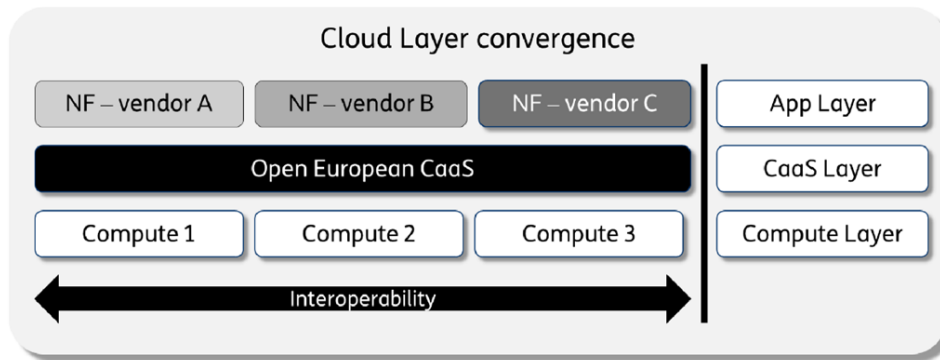


Figure 3: Cloud layer convergence as addressed by Sylva and shown in [51].

To sum up, the technical challenges that Sylva addresses are [50]:

- Network performance: Implementation of identified performance requirements.
- Distributed cloud: Provide an architecture that manages cloud infrastructures.
- Energy efficiency: Measuring consumption and integrate optimisation mechanisms.
- Security: Continuous integration of security requirements.
- Openness: The modular design of the developed architecture allows to continuously integrate other open-source components.

Organisation of Work

Sylva is organized in five Working Groups (WG), as follows [49]:

- WG01 Cloud Stack Development: Focusing on the development of the infrastructure stack.
- WG02 Validation Center: Focusing on the validation of the NFs.
- WG03 Security Requirements: Ensure that Sylva follows the EUCS level 3 security European certification scheme.
- WG04 Energy Efficiency: Preparation of features regarding energy efficiency.
- WG05 Communication and Adoption: Promotion of the status and usage of Sylva.

Moreover, a TSC is established to oversee all technical aspects of Sylva and the TSC meetings are open to the public.

3.2.8 CAMARA

Introduction

CAMARA is an open-source project in the Linux Foundation and it aims to define, develop and test APIs for the telco industry [50]. The adoption of these standardised APIs will enable seamless customer experience and application portability. CAMARA was launched in February 2022 with 22 initial partners, including operators, vendors and hyperscalars (e.g. AT&T, Ericsson, Nokia, GSMA, NGMN, Orange, Vodafone, Telefonica, Google Cloud). Currently, there are more than 1100 contributors and 396 organizations participating in the project [51]. Moreover, CAMARA consists of more than 26 API families and sub-projects. In September 2024, CAMARA made available its first major release 'Meta-Release Fall24', containing 25 APIs [51]. Furthermore, CAMARA collaborates with the GSMA Operator Platform Group on API requirements and publishing API definitions and APIs. Different showcases of the APIs developed by the joint work of CAMARA and GSMA Open Gateway APIs are available in [52] and API status per operator and country can be found in [53].

Topics addressed

Telco network capabilities allow the extraction of information from the network and the configuration of the network. In 5G, it is envisioned that the network will securely expose its capabilities and allow applications and third parties to communicate with the network in a service based approach, hence enabling Network as a Service (NaaS) [50]. CAMARA aims to provide an abstraction from Network APIs to Service APIs, which will enable user-friendly APIs development, satisfy data privacy and regulatory requirements and facilitate application to network integration [50]. Moreover, CAMARA addresses availability across networks, platforms and countries [50]. CAMARA is only focusing on the northbound interface, i.e. between the operator/network and the capability consumer/application and its work is complementary to the Operate APIs developed by the TM Forum [54]. Overall, with the CAMARA APIs, the network capabilities can be more easily exploited, develops more easily obtain access to network information and new applications can be developed [55].

Organisation of Work

CAMARA currently consists of 26 sub-projects, with each sub-project developing and maintaining an API family. All sub-projects are listed in [56]. Additionally, there are 5 working groups, namely, API backlog, commonalities, identity and consent management, marketing and outreach, and release management. The working groups span over more than one sub-project. Moreover, a TSC oversees all technical aspects of CAMARA and the TSC meetings are open to the public. Furthermore, in the TSC there is one non-voting participant from both GSMA and TM Forum [57].

3.2.9 SNS JU Policy WG on 3C Networks

Introduction

The European Commission has developed a strategic white paper providing a vision on the future Digital Network Infrastructures: *WHITE PAPER How to master Europe's digital infrastructure needs?* [2]. Digital networks are undergoing a transformation where connectivity infrastructure is converging with cloud and edge computing capabilities. Convergence of European electronic communications networks and cloud services to an EU “Telco Edge Cloud”, as envisaged in the Industrial Technology Roadmap of the European Alliance for Industrial Data, Edge and Cloud could become a major enabler for hosting and managing network virtualised functions, as well as for bringing complementary services addressing the rapidly growing markets for Internet of Things-related products and services. Yesterday’s separation between “traditional” electronic communications networks/service providers and cloud or other digital service providers will tomorrow be superseded by a complex converged ecosystem. The “softwarisation” and “cloudification” of the next generations of electronic communications networks hold the promise of efficiency gains for all sectors, but also present new challenges in terms of energy consumption (e.g. Open Radio Access Network in cellular networks).

Creating the “3C Network” - “Connected Collaborative Computing”: The goal is to foster a vibrant community of European innovators, creating the “Connected Collaborative Computing” Network (“3C Network”), an ecosystem that spans semiconductors, computational capacity in all kinds of edge and cloud environments, radio technologies, to connectivity infrastructure, data management, and applications.

The SNS JU is the current EU platform for R&I funding towards 6G systems in cooperation between industry and public actors. One of its main objectives is to leverage the EU’s strength in network supply towards the broader value chain including cloud and software as well as devices and components.

Topics addressed

Regarding Cloud the SNS JU Policy Task Force is mainly working on the *Technological sovereignty on cloudification and distributed computing*. It is possible to have different independent cloud infrastructures that are separately optimised for a specific task or market and interoperability is the key. Additionally it is important to identify open-source activities that will allow European solutions to eventually acquire a global role in a market that is

currently heavily dominated by non-European stakeholders. Therefore, it is key to ensure that, where relevant, the produced solutions are integrated with the research and innovation actions being developed in the context of the SNS JU.

Organisation of Work

The SNS JU Policy Task Force is a closed group which is working under the control of the SNS JU Governing board. All information is not public.

3.2.10 Body of European Regulations for Electronic Communications (BEREC)

Introduction

The Body of European Regulations for Electronic Communications (BEREC) provides regulations related to the digital markets in Europe. BEREC aims to ensure that the EU regulatory framework is consistently applied and to promote an effective internal market in the Telecom market. Moreover, BEREC provides opinion and advice to the National Regulatory Authorities (NRA), the European Commission, the council of the EU and the European Parliament. [58]

Topics addressed

In March 2024, BEREC made available a report on Cloud and Edge Computing Services to elaborate on the impact of cloud and edge computing services on the electronic communications sector and to reflect on their regulatory implications [59]. The report outlines challenges related to additional investment on infrastructures, market concentration and competition, digital sovereignty, sustainability, users' uptake and development of use cases, interoperability, data protection and cybersecurity. Moreover, the report addresses four different aspects where telco and cloud providers are cooperating on:

- Connectivity to the cloud and edge locations,
- Migration of Electronic Communication Network to the cloud, e.g. core network functions, radio access network functions and network operation and orchestration,
- Provision of cloud-based network services, i.e. NaaS,
- Bundled and integrated Electronic Communication Network and Information Technology (IT) services with cloud.

Additionally, focus is given on the needs and risks of API openness. Also, BEREC provides an analysis on the conditions and obstacles in regards to the cloudification of networks and the edge computing connectivity. Finally, the report addresses the interplay among different pieces of EU legislation.

Organisation of Work

The Board of Regulators re-established in 2024, 12 working groups to implement the BEREC Work Program 2024 [60]. Each working group is led by two co-chairs from different National Regulatory Authorities [60]. The current 12 working groups are: regulatory framework, open Internet, planning and future trends, market and economic analysis, digital markets, end users, international roaming, fixed network evolution, wireless network evolution, remedies and market monitoring, cybersecurity and sustainability [60].

3.2.11 European Telecommunications Standards Institute (ETSI)

Introduction

ETSI [61] supports the development, ratifications and testing of globally applicable standards for systems, applications and services in the ICT sector. Moreover, ETSI is recognized by the EU as a European Standards Organisation. ETSI addresses a number of different technologies, including Network Function Virtualisation (NFV)

and Open Source NFV Management and Orchestration (OSM). ETSI Industry Specification Group (ISG) NFV [62] was founded in November 2021 and it develops standards for NFV, as well as sharing experiences of NFV implementations and testing in multi-vendor environments. Starting from Release 3, which was completed in summer 2019, ETSI ISG NFV also addresses Cloud-native virtualised Network Functions (CNF). ETSI OSM [63] develops an open source multi-cloud telco orchestrator stack and enables to capitalize on the synergy between standardization and open source approaches. Moreover, ETSI OSM is in alignment with ETSI NFV and Release SIXTEEN, which was announced in September 2024, enables cloud-native orchestration of cloud infrastructure and applications [64].

Topics addressed

VNFs deliver network services while running in virtualized environments and they are an essential part of 5G networks. However, the deployment of VNFs in cloud environments is not scalable nor agile, which creates the need to evolve VNFs to CNFs. ETSI NFV originates from standardizing VNFs and it still continues to address new developments. Additionally, ETSI NFV extended its work to address developments on CNFs. Specifically, in Release 4 they address the topic of CNFs and container infrastructure management, whereas in Release 5 they focus on the topic of multi-tenancy in the cloud [62]. The orchestration and life-cycle management of both VNFs and CNFs is handled by the Management and Orchestration. ETSI OSM works in alignment with ETSI NFV and aims to enable NFV vendors to deliver their solutions to users in a quick and cost-effective way [63].

Organisation of Work

ETSI NFV is an ISG, which operates alongside the standards-making committees in a specific technology area [65]. Both ETSI members and non-members can be part of ETSI NFV, under specific conditions. Moreover, the work programme is defined within ETSI NFV. Within ETSI NFV, four working groups are defined, namely, NFV Evolution and Ecosystem, NFV Interfaces and Architecture, Security, and Solutions [66]. Additionally, the NFV TSC is established, to which the working groups report to. ETSI OSM is open source and both ETSI members and non-members can participate. As of October 2024, there are in total 43 members and 110 participants to ETSI OSM [67]. For the technical development of the project, multiple Module Development Groups are created.

3.3 Analysis on Topics Addressed by Ongoing Cloud Activities

In the previous section, an overview of different activities addressing cloud has been provided, based on publicly available information. In this section, we summarise the characteristics of each activity and the topics that each activity addresses. That way, a more clear understanding is provided in regard to the research landscape and to the topics that are mainly being addressed in the context of cloud. Specifically, we focus on the following topics, which were deemed as important based on the current developments around cloud that were reported in Section 3.1:

- Characteristics of each activity:
- Focus of the activity: whether it is focusing specifically to the telecommunication sector or it is broader to the IT sector.
 - Deployment: the type of deployment, i.e, industrial, commercial, and validation, that each activity is developing, if applicable.
 - Open source: indication whether the developed solutions are open source or not, if applicable.
 - Specifications: indication whether the activity generates its own specifications.
- Potential topics addressed by activities:
 - Policy/Standardisation
 - Architecture/Infrastructure
 - APIs (North-/South-bound)
 - Interoperability
 - Portability

- Data sharing/storing/handling
- Orchestration and management
- Security
- Environmental sustainability
- Business models

Table 10 provides the overview of the activities based on the above-mentioned aspects and the table has been filled in based on our understanding from the previously conducted overview in Section 4.2. Regarding the topics that each activity addresses, we use a three-star rate system, where the number of stars indicates how much focus is given to the topic and a “-” indicates that the topic is not addressed by the activity. Note that Table 10 does not include the activity “SNS JU Policy WG on 3C Networks”, because no information is publicly available. Moreover, “BEREC” is also not included in Table 10, because it is a regulatory body and only one report related to cloud has been found during our research on publicly available information.

Table 10: Overview of topics addressed by each cloud activity.

Topic	IPCEI CIS	European Alliance	Gaia-X	GSMA	CNTi	Anuket	Sylva	Camara	ETSI
Focus	IT	IT & Telco	IT & Telco	Telco	Telco	Telco	Telco	Telco	Telco
Deployment	Industrial	N/A	Commercial	Commercial	Industrial	Validation	Validation	Commercial	Industrial
Open source	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Specifications	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Policy / Standardization	***	***	***	*	**	*	*	*	*
Architecture / Infrastructure	***	***	**	**	**	***	*	-	*
APIs (N/S)	**	**	***	***	**	***	*	***	**
Interoperability	***	***	***	***	***	***	***	*	*
Portability	***	***	***	***	***	**	***	*	*
Data sharing / storing / handling	***	***	***	**	*	*	*	**	-
Orchestration and management	***	***	**	-	**	***	***	-	***
Security	***	***	***	**	**	**	***	***	***
Environmental Sustainability	***	***	*	-	*	-	***	-	-
Business Models	-	***	**	***	*	-	-	-	-

From the overview in Table 10, it is evident that there are multiple activities focused on the cloudification within the telecommunication sector and that different types of deployments are being developed. Moreover, there is a preference for developing open-source solutions and for standardisation of solutions, either by specifications created within the activity or by contributing to and collaborating with other standardisation bodies. Additionally, topics such as APIs, interoperability, portability and security are significant within the considered activities.

3.4 Recommendations and Upcoming Research Activities

From the different topics that European R&I initiatives address, which were presented in Deliverable 2.1 [1], cloud has been identified as one of the most relevant topics. In digital societies, the telco infrastructure will be integrated with the cloud infrastructure. Therefore, there is a potential dependency on hyperscalers and non-EU players, which could hinder the economy, innovation and data security of Europe. The importance of cloud is highlighted by the white paper paper “How to master Europe’s digital infrastructure needs?” [2] from the European Commission, as well as by the 6G-IA in their position paper “Key strategies for 6G smart networks and services” [16]. Moreover, a workshop on cloud and services has been organized for the SNS Work Programme (see Section 4.5.5).

We identify the following three necessities to stimulate European sovereignty of telco cloud and describe the recent developments to address them:

- **Funding:** It is important to provide funding for research, implementation and testing of cloud networks. This funding is addressed by the draft SNS Work Programme 2026, which is calling for a 15M Euro Stream C project on the implementation of the 3C Network. Additionally, funding is also addressed by the draft Horizon Europe Cluster 4 call, which is calling for an 80M Euro project on telco cloud implementation. Furthermore, funding has also been provided by IPCEI-CIS, which is addressing the federation of IT cloud.
- **Standardisation:** Currently, the 6G use cases are being defined by 3GPP. Thus, it is important to ensure the inclusion of compute-as-a-service with standardised interfaces for a multi-provider business model.
- **Regulation:** The SNS JU Policy WG on 3C Networks has been established and it aims to align the SNS Work Programme as well as influence the policy of the European Commission.

From our analysis on the different ongoing cloud-related activities in Section 3.3, we identified that certain activities are focused on IT cloud, e.g., IPCEI-CIS, whereas other activities are focused on telco cloud / 3C network. Although both types of activities aim for a distributed cloud, they have different focus and hence different requirements, i.e., IT cloud is focused on hosting generic IT applications and telco cloud / 3C network is focused on hosting dedicated mobile networks and mobile edge applications. However, regardless of having different requirements, it may still be beneficial to create synergies in a common approach towards European sovereignty.

4 Establishing Collaboration in Europe

4.1 Introduction

SNS ICE is seen as the ambassador for the SNS programme. For SNS ICE WP2, this implies tasks of establishing and maintaining dialogues at EU level, placing SNS at an EU roadmap promoting the results of SNS, and organising European 6G Workshops and events. This section describes various SNS ICE activities in 2024 towards this ambassador role.

Section 4.2 discusses the process towards establishing a European consolidated R&I input on 6G use cases for the 3GPP SA1 6G use cases workshop in Rotterdam (May 2024). That section is followed by a section 4.3 that describes the various activities undertaken by SNS ICE to disseminate and promote the consolidated R&I use cases input. Section 4.4 lists a number of activities to promote the results of the SNS JU in European R&I. Then, Section 4.5 describes how SNS ICE participated in a number of SNS OPS organised workshop to maintain a dialogue and align with other European R&I initiatives on the SNS JU Work Programme. Section 4.6 lists a number of SNS ICE activities to promote the collaboration between National 6G Initiatives and between these National 6G Initiatives and the SNS JU. Finally, Section 4.7 mentions a number of SNS ICE activities related to maintain and establish dialogues with other initiatives in the area cloud. Section 4 also show a number of workshops and events that have been organised by SNS ICE.

4.2 6G Use Cases Definition in 3GPP

In 2023, Jose Almodovar (chairman of 3GPP SA1) and SNS-ICE team member formulated a plan to organise a 3GPP SA1 6G use cases workshop. The goal was to enable 3GPP SA1 delegates to hear from research alliances around the world and from market representation partners on their views on 6G use cases. Also, the European 6G R&I initiative would be invited to present. This plan was discussed at the 3GPP SA#102 plenary in Edinburgh¹ and endorsed.

At the same time, discussions in Europe (e.g. with the German National 6G Initiative) indicated that there was a vivid interest from different European R&I initiatives beyond the SNS JU to provide input.

A discussion was held involving 6G-IA, Hexa-X-II and SNS ICE delegates on how to organise a European input. End of 2023, the Hexa-X-II project was going to release their Deliverable D1.2 [68] with in there their set of 6G use cases. These use cases were based on earlier work in the preceding Hexa-X project. It was therefore considered that Hexa-X-II would be the best source for 6G use cases within the European 6G R&I initiatives. Nevertheless, it was considered that it would be great if other SNS projects and National 6G Initiatives could provide input.

4.2.1 3GPP Use Cases Workshop – EU Prep – Open Webinar

On 24th Jan 2024, SNS-ICE organized a webinar to foster European collaboration towards a common EU consolidated input towards the 3GPP SA1 6G use cases workshop, to maximize the impact of the EU position. It was agreed that the starting point for the EU Use case definitions would be the Hexa-X-II use cases, which were presented by Hexa-X-II. Other SNS projects and National 6G Initiatives would have the possibility to provide feedback and propose modifications. SNS ICE partners provided the necessary templates, and guidelines on how to provide feedback. The session attracted approximately 60 participants, from the SNS JU office, the SNS projects and National 6G Initiatives.

4.2.2 3GPP Use Cases Workshop – EU Prep – Final EU Workshop

Feedback on the Hexa-X-II use cases was provided by SNS projects, 6G-NTN, 6GShine, TrialsNet, NANCY, SEASON, and FIDAL, and by the National 6G Initiatives 6GPlatform (Germany), FNS (The Netherlands), and Restart (Italy).

¹ https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGS_102_Edinburgh_2023-12/Docs/SP-231619.zip

This feedback was incorporated in the Hexa-X-II use cases to create a consolidated European R&I 6G use cases input.

At a workshop on April 15th, a summary of the feedback received and the way this feedback was implemented in the use cases were presented. This way consensus was achieved that this would be the consolidated European input on 6G use cases. Because the detailed slide set on use cases would be too long for the limited time that was available to present at the 3GPP SA1 6G use cases workshop, also a draft high level presentation for the workshop was given. The workshop concluded with a general agreement that this would be the way to present the consolidated European R&I input.

4.2.3 3GPP SA1 6G Use Cases Definition Meeting

During the 3GPP SA1 workshop on 6G use cases in Rotterdam (8-10 May 2024)², Gustav Wikström presented the European view on 6G use cases (snapshot depicted in Figure 4), to an audience of approximately 500 people (200 in-person and approximately 300 people online). The presentation was part of a session in which R&I initiatives from around the world (North America, Europe, India, China, Korea and Japan) were invited to present their views on 6G use cases. Other session at the workshop focused on the views from operators, and on the views from verticals. Each of these sessions included presentations and a panel discussion (see SNS ICE D1.2 [69] for more information). On the final day of the workshop there were presentations from ITU-R and 3GPP with a panel on synergies for 6G between ITU & 3GPP.

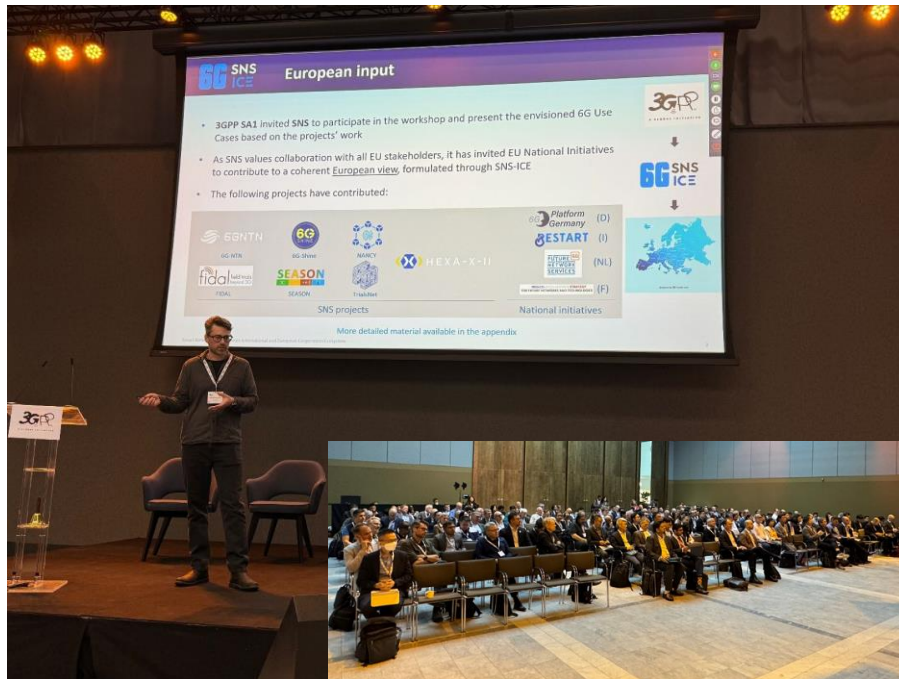


Figure 4: Presentation of European consolidated use cases and audience at 3GPP SA1 workshop on use cases, Rotterdam.

4.3 Disseminating the 6G Consolidated Use Cases

The consolidated European R&I use cases input to the 3GPP SA1 workshop on 6G use cases in Rotterdam was an important success; both as a collaborative effort and as an R&I input to standardization. It represents the European R&I view on 6G use cases as was provided to 3GPP standardization. The SNS ICE project therefore has

² <https://www.3gpp.org/news-events/3gpp-news/sa1-6g>

taken great effort to further disseminate the 6G consolidated use cases, through presentations at conferences and by including it in the 6G-IA White paper on the European Vision for the 6G Network Ecosystem [70].

4.3.1 EU Collaboration Convened Session at EuCNC 2024

From the perspective of the wider research community in Europe, it was of interest what the consolidated European view on 6G use cases is and how that view was established. The 3GPP SA1 use cases workshop in Rotterdam (8-10 May 2024) was restricted to 3GPP delegates only. Therefore, SNS ICE organized a convened session on “European vision on 6G use-cases” during EUCNC (5th of June)³ to share for the first time the results of the 3GPP workshop (snapshot from the workshop depicted in Figure 5).

Toon Norp from the SNS ICE project presented the European consolidated use cases and the process to achieve that consolidated view. Presentations from Jos Berière (Future Network Services – The Netherlands), Hans Schotten (6G Platform – Germany) and Dorin Panaitopol, (Thales – 6G NTN project) showed what input on use cases other projects and national initiatives had provided for the consolidated European use cases. The presentations were followed by a panel discussion, moderated by Kostas Trichias from the SNS ICE project, with standardization experts and industry leaders. The panel discussed where there was consensus and where a difference of opinions on 6G use cases between the different regions and market representatives in the 3GPP SA1 workshop. Furthermore, the panel discussed how standardization will make use of the presented views.



Figure 5: Professor Hans Schotten presenting the German input.

4.3.2 State Representative Group Meeting at EUCNC 2024

Co-located with EUCNC 2024 in Antwerp, the SRG organised a meeting on the theme of standardization. Colin Willcock from the SNS ICE project presented the European consolidated R&I input for the 3GPP SA1 6G use cases workshop in Rotterdam (snapshot depicted in Figure 6). The attendees at the meeting recognized the major achievement of creating a common European input to standardisation.

³ <https://www.eucnc.eu/2024/www.eucnc.eu/programme/special-sessions/convened-session-3/index.html>



Figure 6: Presentation of 6G use cases at State Representative Group meeting during EUCNC.

4.3.3 Berlin 6G Conference

The Annual Networking Event of the German 6G Program – organized by the 6G Platform Germany was held at the Berlin Congress Center, from 2-4 July 2024 attracting around 1000 participants from Germany, Europe and around the world. Toon Norp from the SNS-ICE project presented the main takeaways from the different sessions at the 3GPP SA1 workshop in Rotterdam, with a focus on the European consolidated use cases. A presentation from Colin Willcock provided an update on the overall European level 6G research activities focusing on the SNS-JU. The Berlin 6G Conference was also an excellent event to foster understanding and cooperation between National and European level 6G research.



Figure 7: Presentation of 6G use cases at Berlin 6G Conference.

4.3.4 Fraunhofer FUSECO Forum

In November 2024, Jose Almodovar, representing the SNS ICE project attended the 12th edition of the FUSECO Forum⁴ organized by Fraunhofer FOKUS institute in Berlin. This event represents an excellent opportunity to engage with the German telecom community and promote diverse activities. In this 2024 edition, the SNS ICE message focused on the European view of use cases presented by SNS ICE during the 3GPP SA1 workshop in Rotterdam. Also, more information about 3GPP deadlines and contribution opportunities for 6G was included in the presentation from Jose Almodovar.



Figure 8: Jose Almodovar presenting at the FOKUS FUSECO Forum.

4.3.5 Online workshop Chinese IMT2030 Promotion Group with 6G-IA

On the 26th of November, SNS ICE organized an online workshop between 6G-IA and its Chinese counterpart the IMT2030 Promotion Group. At the workshop, Toon Norp presented the European 6G use cases for a selected audience from the Chinese IMT2030 Promotion Group and from 6G-IA. There were also presentations from the Chinese use cases, presentations from the European and Chinese side on 6G technological enablers and architecture aspects, and discussion on these various aspects.

4.3.6 6G Evolution Summit

The 2024 edition of the 6G Evolution Summit⁵ included a number of presentations and panel discussions around topics such as:

- Defining the 6G Future: Use cases, Current Progress and What to Expect;
- 5G Advanced – Bridging the Gap Between 5G and 6G;
- Navigating the THz Spectrum with Artificial Intelligence/Machine Learning (AI/ML);
- Building AI and GenAI into 6G, and;
- Delivering on Sustainability Objectives with 6G Connectivity.

The keynote speech by Colin Willcock in the first session provides an introduction to, and background of, the SNS-JU. In addition, it discussed the combined European 6G use case presented at the 3GPP SA1 workshop with a brief introduction to the 6 use case families identified with examples.

⁴ https://www.fokus.fraunhofer.de/ngni/events/fuseco-forum_2024

⁵ <https://www.fierce-network.com/fiercenetworkcom/6g-evolution-summit-2024>

4.4 Promoting the Activities of SNS JU within European R&I

In conjunction with its role of SNS ambassador, SNS ICE has participated in the following events to promote the activities of SNS JU within European R&I.

4.4.1 European Microwave Week 2024

On 26 September, the SNS ICE project and 6G-IA were represented at the 2024 edition of the European Microwave week conference which took place in Paris. This is a 2000+ participants event and the most important European event dedicated to Radio Frequency and microelectronics, with also more than 100 exhibition stands. In that context, a dedicated 6G workshop was organized by CEA-LETI with the support of local industrial stakeholders like STM. The participation of SNS representatives is part of the significant SNS efforts to increase activities in the microelectronics domain and to prepare the European microelectronics ecosystem to be well positioned on the future opportunities that 6G will offer, at network or device level. In that context, the 6G workshop attended by about 100 persons allowed to further announce the upcoming microelectronics actions on Front End Module planned under the SNS WP 2025, and to outline the expected outcome from the SNS perspective, including downstream opportunities of collaboration with the Chips JU, notably the utilization of the Pilots Line that could greatly help to later industrialize the resulting products. The event was also an occasion to take stock of the various programmes dealing with 6G microelectronics, notably the French PEPR (54 M€) and to recap the current State of the Art for key technologies like Si, SigE, Inp, optical, Fdsoi in view of future realization of European 6G microelectronics modules.

4.4.2 Presentation of the JU Networks and Services at the Financements Européens des Télécoms

The Financements Européens des Télécoms⁶ took place on October the 1st at Versailles. About 100 people from the French research eco-system took part mostly academics but some industry participation especially from SMEs. On behalf of SNS-ICE, Colin Willcock gave an introductory presentation on the SNS-JU highlighting the possibilities and advantages of participation to the French audience. The event also allowed some dialogue with French government representatives about better coordination between National and European 6G research moving forward.

4.4.3 Presentation at UKTIN International & Horizon Engagement Conference

On December 4th, 2024, the SNS ICE project, through Alex Kaloxylos (6G-IA) participated in the UKTIN International and Horizon Engagement Conference in London. Dr. Kaloxylos was one of the key speakers at the event and he presented the “Current Horizon plans and opportunities- The 6G-IA perspective”. The key part of his presentation was to inform UK stakeholders about the 6G-IA activities, its involvement in the SNS JU, the governance of the SNS JU and the priorities that 6G-IA through the activities of SNS-ICE has proposed to the SNS JU. Dr. Kaloxylos answered various questions about the current achievements of the SNS JU and the promising future R&I activities. Dr. Kaloxylos also chaired a panel of experts⁷ about how UK stakeholders can increase their chances of participating in a successful proposal for SNS Horizon Europe.

⁶ <https://www.horizon-europe.gouv.fr/financements-europeens-des-telecoms-presentation-de-la-ju-smart-networks-and-services-37602>

⁷ <https://www.linkedin.com/feed/update/urn:li:activity:7270046074017357827/>



Figure 9: Panel discussion at the UKTIN International & Horizon Engagement Conference.

4.5 Alignment with other European R&I Initiatives related to the SNS JU Work Programme

In April 2024, a series of exploratory workshops (see Table 11) were organized by SNS-OPS in the framework of the Impact Assessment and Facilitation Action (IAFA) initiative. The workshops, listed on Table 11 below, had a duration of one full day each and took place in the White Atrium building in Brussels under the auspices of the SNS JU and Directorate-General for Communications Networks, Content and Technology (DG-CNECT). SNS-ICE very actively participated in those events, by contributing several experts and, in some cases, chairs (e.g., for the wireless communication technologies workshop). The objective of those workshops was two-fold:

- 1) To develop a list of technical priorities for research and innovation in 6G and how this could be implemented in a structured way: short-term 2025, medium-term 2026 and long-term 2027; and
- 2) To identify synergies with other instruments such as other JUs, PPPs, IPCEI, EUREKA Clusters, national programs and other initiatives, especially in the timeframe of the next 3 years.

Before the meeting, all participants prepared and shared a presentation of up to five slides about their proposed strategic orientations for this domain. From them, they derived the needed technological developments, together with an identification of their maturity level. Specifically, workshop participants were required to identify (i) the top topics of importance for their organization along with the current TRL levels; (ii) the expected timeline for each topic (short, medium, long) for the foreseen TRL after the completion of the R&I activities; (iii) synergies with other instruments/programmes; and (iv) topics that are currently missing for 6G, that is, not already covered by SNS.

The companion SNS-ICE deliverable D1.2 focuses on the first objective and reports on how the workshops helped shape the SNS R&I work programme 2025 and, potentially, those of the coming years. This deliverable, on the contrary, focuses on the second objective. Specifically, it discusses the role of and main synergies identified with the aforementioned instruments and other entities and associations with the ultimate purpose of aligning/harmonizing the corresponding work programmes. On the latter, further details are provided in the next subsections.

Table 11: Series of IAFA workshops on 6G research priorities organized in Brussels.

Scope	Date	Synergistic work programmes/initiatives
Photonics	10 April 2024	Photonics 21, Chips JU, European Space Agency (ESA).
Non-terrestrial Networks	11 April 2024	European Space Agency (ESA)
Security	12 April 2024	European Cyber Security Organisation (ECISO), IPCEI-CIS, Quantum Flagship, European Cybersecurity Competence Center
Wireless communication technologies & signal processing	15 April 2024	Chips JU
Cloud and service provision	16 April 2024	IPCEI-CIS, Cluster 4 (Large Scale Trials on end-to-end infrastructure; advanced computing and big data).

Regardless of the specific research area, the overall methodology of JU cooperation and alignment revolves around the following axes:

- A topic is fully addressed by the proposed other initiative or organisation (ESA, Chips JU or Photonics 21), with loose information channels between stakeholder in SNS projects and the other initiative or organisation.
- From the SNS perspective, requirements from the system and networking perspective can be provided. The other initiative or organisation may provide information for 6G system design in SNS.
- For implementation purposes the other initiatives or organisations may provide components for SNS pilots and trials. Stakeholders from the other initiatives or organisations can participate in respective SNS pilot or trial projects. Other means could be workshops, webinars, etc.
- Possibility for mutual participation in calls and potential coordination of call topics, which are relevant for both sides.

4.5.1 Photonics

In this workshop, several **experts from the Chips JU and Photonics 21** participated. Most of the proposed priorities are networking-related and can be implemented to a certain extent by the SNS JU within the available budget framework. Other areas like components and details on satellite links should be addressed in cooperation with Chips JU Photonics 21 and ESA. From the SNS perspective, a cooperation is desired with other initiatives or organisations in the following areas:

- Optical NTN domain, space to ground links the link design for inter-satellite and space to ground links should be provided by ESA. This can be integrated in 6G systems and networks.
- Co-package electronic photonic integration and the provision of components should be discussed with Chips JU and Photonics 21 by providing requirements from the SNS perspective and the integration of components in SNS pilot and trial projects.

The envisaged approach to JU collaboration was that networking priorities should be addressed by SNS calls for proposals, where members from other initiatives may participate with own proposals or in joint consortia. Photonics components may be contributed where gain members from the different communities may participate. For example, pilot and trial systems can integrate components from the photonics side to demonstrate the overall network performance.

4.5.2 Non-terrestrial networks

The trend for integration of Non-Terrestrial Networks (NTN) with Terrestrial Networks (TN) started already a few years ago, with the implementation in the early 2010 of several 5G-PPP, ESA or national projects looking more specifically into satellite as an access or backhaul component of 5G. For 6G, it was proposed that SNS-JU should focus on a “TN-NTN *Unification* Initiative” that would cover architectural and technological issues requiring a very tight cooperation between the SNO and the MNO’s, towards a seamless TN-NTN communication continuum, and catering for a multiplicity of possible business models across the various domains.

The team of experts in this workshop included **two representatives from the European Space Agency**. For this particular area, it is of utmost importance to establish synergies with and leverage other initiatives. The workshop confirmed that ESA and National Space Agencies are strongly engaged in developing many critical technologies which are needed for 6G network, (e.g., MIMO from space, new antenna design for satellite, beam generation, regenerative or software defined payloads), for instance, under the ARTES programme. In that context, and considering i) the very strong space focus of these critical technologies; and ii) the magnitude of the needed budget and potential requirement for availability of in orbit space resources to reach impactful results, it was proposed that these technologies would not (or only marginally) be directly addressed in the next phases of R&I implementation of the SNS-JU. Of course, this does not prevent specifications for these technologies to be reused under SNS projects if needed at system or subsystem levels to address their workplan. However, the focus should be on the unification aspects described in the first paragraph.

On top of that, light coordination mechanisms such as regular exchanges of information between the projects supported by ESA and SNS, possibly framed by an MoU were proposed for the 2025 and 2026 calls of the SNS R&I Workprogramme.

4.5.3 Security

This workshop counted with one representative of the **European Cyber Security Organisation** (ECSSO) a European, cross-sectoral membership organisation that contributes to developing cybersecurity communities and building the European cybersecurity ecosystem. Complementarily, programme officers from DG-CNECT working in the security domain attended as well.

A number of research topics for collaboration with synergistic initiatives were identified in the course of the workshop. Notably, security of the cloud continuum/6G is a fertilized area for collaboration with the existing **IPCEI initiative** and/or other high-performance computing calls under the umbrella of horizon Europe or the German 6G initiative. This includes topics such as converged security architectures allowing interworking within AI-native 6G including Cloud Continuum and IoT; or continuous security assessment.

Quantum topics (e.g., Quantum Key Distribution) and quantum technologies integration may be handled through existing **Quantum Flagship** and related national initiatives.

Last but not least, 6G security has specific application of numerous security topics which fit under the umbrella of the **European Cybersecurity Competence Center** (ECCC). The experts strongly recommended to reinforce and synchronize the actions in research and Innovation and even beyond for regulation/certification. This includes areas such as zero-trust integration including Confidential computing, Data Centric Security and advanced cryptographic technologies applications; exposing security attributes and value, intent-based security, or security measurement and certification.

4.5.4 Wireless communications technologies and signal processing

Workshop participants included key players from the telecommunications industry (mobile network operators, equipment vendors, research centres and academia). Besides, other players from the microelectronics sector were invited too, to identify further synergies in this domain. This included one participant from Inside IA/LTU who is a member of the **core group** in charge of preparing the **Electronics Communications Systems Strategic**

Research and Innovation Agenda (ECS-SRIA), as well as **SOITEC**, a key stakeholder from the ECS/Chips JU community.

Table 12 reveals that virtually all the research topics proposed in the workshop fall under the umbrella of the SNS JU. However, it also evidences that a number of synergies with sister JUs (Chips JU, EuroHPC JU), and related initiatives (IPCEI) exist. Clearly, several subtopics under multi-processor SoC/accelerators and flexible HW architectures go well beyond the scope of SNS (e.g., RAN silicon, energy-efficient ASIC technology). Whereas SNS projects are likely to leverage and/or integrate those technologies, their development falls under the umbrella of the Chips JU. Also, RF Technologies for FR3 implementation (T-13) seems to be in close alignment with or at least closer to the SRIA of the Chips JU. Therefore, one possible way forward would be to address those developments as part of the Chips JU efforts, for instance in relation with its cross-sectional technology 2.1 (Edge Computing and Embedded Artificial Intelligence) in the ECS Strategic Research and Innovation Agenda 2024. On the contrary, Efficient support of mmWave and sub-THz communications (T-02) and RF technologies for FR3 implementation (T-13) could make a better fit into the FEM initiative or, alternatively, in selected parts of the CJU Workprogramme in relation with e.g., its cross-sectional technology 2.2 (Connectivity) in the ECS SRIA.

As for the topics that received less attention in this workshop, namely, Optical-Wireless Convergence (T-6), Integration with NTN (T-9), Security/privacy (T-10), and Cloud Architectures (liaison) (T12); there exist clear synergies with other parts of the SNS Workprogramme that should be explored. Likewise, synergies could also be sought with Photonics 21, ESA, Cluster 4 (Connected–Collaborative –Computing initiative 3C) and the existing CIS IPCEI initiative.

Table 12: Priority topics and synergies identified in the wireless workshop.

Nr.	Topic	Short (2025)	Medium (2026)	Long (2027)	Specific/Synergy
1	MIMO, Massive MIMO, and MIMO evolutions	x			SNS
2	Efficient support of mmWave and sub-THz communications		x		SNS, CJU
3	AI & Semantic communications	x	x		SNS
4	Spectrum sharing and RAN co-existence	x			SNS
5	Open RAN	x			SNS
6	Optical-wireless convergence			x	SNS, Photonics 21
7	Network as a sensor and positioning		x	x	SNS, CJU
8	Multi-processor SoC/accelerators, flexible HW architectures	x	x		SNS, CJU, EuroHPC JU
9	Integration with NTN			x	SNS, ESA
10	Security / privacy	x			SNS
11	Physical layer technologies for enhanced spectral efficiency	x			SNS
12	Cloud architectures (liaison)	x	x		SNS, Cluster 4, CIS IPCEI
13	RF technologies for FR3 implementation	x			CJU
14	Sustainability	x	x	x	SNS, CJU

4.5.5 Cloud and service provision

In this area, apart from the SNS JU activities one needs to consider related activities in: the IPCEI-CIS, the Cluster 4 activities on advanced computing and big data, the anticipated cluster 4 call on large scale-trials for e2e infrastructures. For this reason, top representatives and **high-ranked officers from the EU Cloud Alliance and DG-CNECT in charge of Cluster 4** calls were invited to participate and attended the workshop.

Although the IPCEI-CIS has a concrete plan to “deliver a first industrial deployment (FID) of the software components necessary to establish and operate a distributed, openly accessible and interoperable EU Multi Provider Cloud Edge Continuum” and Cluster 4 activities on advanced computing and big data are working on modern IT computing platforms for a cognitive cloud edge computing continuum, future calls of the SNS JU and the anticipated Cluster 4 call on large scale-trials for e2e infrastructures are under preparation. To come up with a realistic synergetic plan, one needs to consider the time-plan of the afore initiatives as shown in Figure 10.

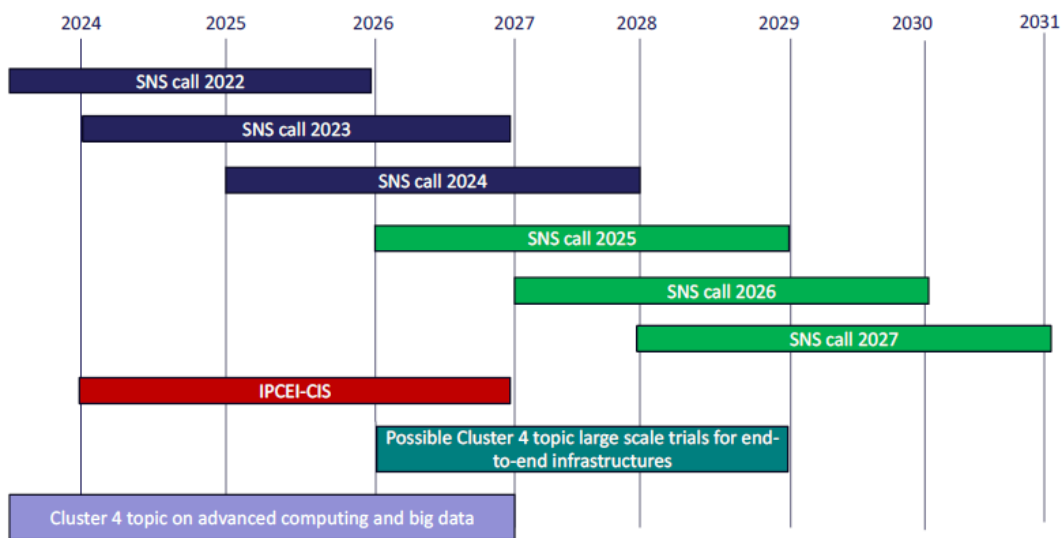


Figure 10: Timeplan for the SNS calls, IPCEI-CIS and Cluster 4 on large scale trials for end-to-end infrastructures.

In the above figure one can identify that IPCEI-CIS results could be used for further extensions towards 6G 3C networks and services from the SNS calls on 2025 onwards, combined with the SNS results from previous calls (i.e., call 2022 and call 2023). As similar activities are considered for the anticipated cluster 4 call on LST on end-to-end infrastructures some differentiation is needed compared to the 6G activities. This differentiation factor could be that this call could focus on how to support cloud principles and enhance service provision considering existing 5G and 5G advanced networks. This call could also take into consideration early SNS JU results from calls 2022 (e.g., on Stream A) and 2023 to test them in trials. Besides, the results from all the above instruments could be further used in the possible future IPCEI on infrastructure. It is worth noting that one of the key results from the SNS JU projects is the standardization of the developed solutions in the context of 6G standardization activities.

4.6 Stimulating Collaboration with National 6G Initiatives and SNS JU

In addition to the SNS JU, there exist several national 6G initiatives in EU Member States. In total, these national 6G initiatives provide more than 2 billion Euro worth of funding on top of the 900 million Euro SNS JU funding. It is expected that the total European public funding of 6G R&I is around 3 billion Euro. Because

all these European R&I initiatives have a common goal of creating a leading role for Europe in 6G, it is relevant to stimulate collaboration between these initiatives.

In alignment with the SNS Office, and the SNS SRG, SNS ICE has been active to stimulate collaboration between National 6G Initiatives and between National 6G Initiatives and SNS JU. This section describes a number of activities that SNS ICE has undertaken.

4.6.1 Restart Meeting

During the Restart Plenary Dissemination workshop (30-31 January 2024, Bologna)⁸, the Italian Restart National 6G Initiative organized a panel on collaboration between national initiatives. SNS ICE supported this panel session by providing the main contacts for the national initiatives. The panel covered delegates from the national 6G initiatives in Germany, France, Ireland, Italy, Finland, The Netherlands, and Spain. Furthermore, TNO represented SNS ICE in the panel and discussed activities that SNS ICE is taken to support the collaboration (snapshot depicted in Figure 11).



Figure 11: Panel on national initiatives at Restart workshop.

4.6.2 Panel on National Initiatives at EUCNC 2024

The collaboration between National 6G Initiatives was the focus of a workshop⁹ ‘Research on 6G: what’s in EU Member States?’ organised by two representatives of national initiatives, Stanislav Stanczak from the 6G Platform Germany and Umberto Spagnolini from the Italian Restart initiative. The workshop provided presentations from several national initiatives about the structure and activities of these national initiatives, and a number of presentations on from industry leaders on their vision. There was also a panel discussion discussing ways to improve collaboration across and identifying topics of interest for collaboration. Organising workshops on joint 6G topics of interest was identified as a suitable way to collaborate between the National Initiatives. SNS ICE provided assistance for this workshop by providing contact details of the speakers from the various national initiatives and Toon Norp represented SNS ICE in the panel.

⁸ <https://www.fondazione-restart.it/2024/01/31/restart-plenary-dissemination-workshop-january-30-31-bologna-italy/>

⁹ <https://www.eucnc.eu/2024/www.eucnc.eu/programme/workshops/workshop-1/index.html>



Figure 12: Panel on national initiatives at EUCNC.

4.6.3 Paper and presentation on national initiatives at EUCNC

The SNS ICE project has provided a report on National 6G Initiatives to the SRG and also reported on the seven large National 6G Initiatives in the SNS ICE Deliverable 2.1 [1]. Based on this overview of National 6G Initiatives, SNS ICE produced a paper on 6G Research & Innovation Activities in Europe, which was accepted for the EUCNC 2024 in Antwerp [71]. The paper was presented at EUCNC 2024 by Prachi Sachdeva.



Figure 13: Presentation of paper on national initiatives at EUCNC.

4.6.4 FNS and Hexa-X II Workshop

A joint workshop between the Hexa-X-II, the European SNS 6G Flagship project, and the Dutch 6G National Initiative FNS took place on September 23rd, 2024 in The Hague¹⁰. The workshop included presentations on various aspects of 6G Technology covering a wide range of topics, including: 6G Use Cases, Sustainability, Network Architecture and Radio Aspects. With approximately 60 attendees, the workshop was a great platform for knowledge exchange, identifying synergies, and networking between the SNS flagship project and one of the large National 6G Initiatives. The workshop was chaired by Toon Norp from the SNS ICE project.



Figure 14: Speakers at the FNS – Hexa-X-II workshop in The Hague.

4.6.5 Regular Online Meetings Between National Initiatives

There have been several conference sessions, panels, and other opportunities for discussion between the different national initiatives. However, each of these opportunities for collaboration was structured differently and had a different agenda. It became apparent that a collaboration between the national initiatives would benefit from more structured meetings with an agenda and action points. Therefore, SNS ICE has facilitated a set of regular online meetings between the national initiatives. The first meeting was held online on the 6th of September 2024, and by end of 2024 two more meetings have been held.

The following simple terms of reference were agreed:

Terms of Reference NI collaboration meetings

Goal: Goal of the collaboration meetings is to create synergies between the different national 6G initiatives in Europe

Participants: (Representatives of) National Initiatives (NIs)

Decision making: Any meeting participant can propose collaboration activities. Participation in collaboration activities is on voluntary basis. Decisions on collaboration activities are unanimously agreed, between the national initiatives that want to participate.

Minutes: Minutes will contain attendees, action points, agreements and news and will be distributed to all national initiatives

¹⁰ <https://hexa-x-ii.eu/future-network-services-and-hexa-x-ii-host-joint-workshop/>

The national initiatives, 6GFlagship (Finland), 6GBridge (Finland), France, Germany, Ireland, Italy, The Netherlands, and Sweden have been regularly attending the collaboration meetings. Toon Norp from SNS ICE has been chairing the meetings and provided the minutes.

Note that the collaboration meetings between national initiatives are different from the State Representative Group. The State Representative Group has representatives from the different EU member states to discuss and provide feedback on the SNS JU. These state representatives are sometimes also involved in the national 6G initiatives in their member states, but many states do not have a (large) national 6G initiatives or the state representatives is not directly involved in the national 6G initiatives. The national 6G initiatives on the other side are often public private partnerships that cannot be represented well by a member state representatives who would only represent the public side. Although different national initiatives have different organisational structures, the collaboration meetings between national initiatives largely involves attendees that are active on a day-to-day basis within their national 6G initiatives.

One specific way of collaboration identified in the collaboration meetings is the organisation of webinars on specific topics that are of interest to the national initiatives. Currently, SNS ICE lends these activities logistics support for organisation and also helps promoting them via its social media channels.

4.6.6 Techritory 2024 co-creation event “Synergies between 6G NI and SNS JU”

Achieving synergies between National 6G Initiatives and SNS JU was the topic of a Techritory co-creation event organised by SNS ICE on October 31st, 2024¹¹. The goal of the session was to look at the work programme of SNS and the different national initiatives if there are specific topics that are missing or where more synergy can be achieved between the work programmes.

To prepare for the co-creation event, all National 6G Initiatives were asked to fill in a questionnaire. The questionnaire contained a list of activities from the SNS Work Programme. Each of the National 6G Initiatives was asked which of these activities they were working on, when would results be available and what would be the TRL level of the results. The questionnaire was completed by most of the National 6G Initiatives; 6GFlagship, Sweden, Germany, France (for the PEPR part of their programme), FNS, Restart, and Connect Ireland.

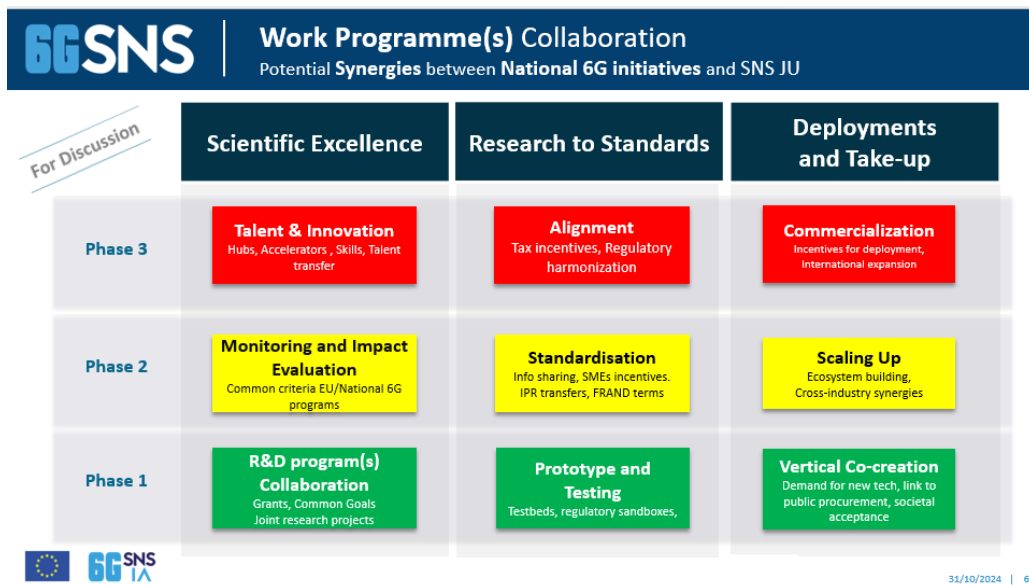


Figure 15: Javier Albares (Head of Programmes SNS Office) presented several areas for potential synergies.

¹¹ <https://www.techritory.com/sns-ice-national-initiatives/>

The agenda of the co-creation session included presentations and a follow on discussion where speakers, representatives from the national 6G initiatives, leadership of the State Representatives Group, and other delegates discussed on what topics should get more attention in the work programmes and what could be done to improve synergies across European 6G R&I. Presentations included:

- Perspective of the SNS office on collaboration with NIs - Javier Albares, Head of Programmes SNS Office (snapshot provided in Figure 15)
- Synergies between SNS JU and NIs on 6G - Carles Anton Haro;
- Presentation of SNS OPS survey results - Kostas Trichias;
- Results of activities Questionnaire - Toon Norp;
- Ideas for synergies presented by the National Initiatives. – short pitches from Italy, Sweden, The Netherlands, and Ireland.

An overview of the results of the questionnaire is provided in **Annex 1**. The results show that most of the main architecture and radio activities have quite a large coverage amongst especially the larger or more established National 6G Initiatives. There is quite some overlap of activities. Some topics from SNS are somewhat less addressed by the National 6G Initiatives. It could be worth ensuring that these topics are addressed (or continue to be addressed) in upcoming SNS work programmes (e.g. the SNS Work Programme 2026). These topics include:

- Spectrum sharing and integration of multiple frequency bands
- Security related topics
- Short range communication protocols
- Deterministic networking

Topics that are addressed by almost all National 6G Initiatives could benefit from more synergy through collaboration among the National 6G Initiatives. These topics include:

- Cloud continuum and orchestration and management
- Terahertz communications and millimetre wave

Where the questionnaire did not give much information is on timing of research activities. The idea was also to identify at what time SNS could take specific types of results (e.g. implemented testbeds) from the National 6G Initiatives. However, providing information on TRL levels for a large number of activities proved a hurdle for several of the National 6G Initiatives and information was not always provided. Furthermore, there is a large difference in timing, e.g. the German National 6G Initiative almost has completed its first phase whereas other National 6G Initiatives have only just started. Hence it is hard to identify what kind of results can be expected and when, across the National 6G Initiatives.

The National 6G Initiatives were also asked to identify specific topics that they believed need more attention. The following topics were identified:

- Services layer. The SNS Work Programme pays attention to cloud and 3C networking. But more attention should also be provided to the Over-the-Top services layer, where now North American Big Tech companies dominate the market.
- Security by design. Each round of SNS calls, there is one call on Security which is a “catch all” for all kinds of security techniques. But security is missing in other calls. Every call should have security integrated into it as one of the aspects to promote “Security by Design”. Considering that Trustworthiness is one of the three foundational pillars of 6G, security should be taken more seriously in all the calls.
- Spectrum sharing. With the limited availability of optimal spectrum, sharing spectrum at some point in time will become a necessity.
- Intelligent agents. There is a lot of ongoing work on applications from verticals that are hosted in the edge. But less so for intelligent agents, small applications that are offloaded by devices or persons into the edge. Hosting millions of interconnected agents will provide a challenge.

The co-creation session also included an open discussion. Here also leading members from the State Representative Group took part. Some specific suggestions from the discussion that are more in the scope of the State Representative Group were:

- Involve SMEs in different countries in open calls. Often SMEs have difficult to get involved in SNS projects. National 6G Initiatives can help to get SMEs within their countries to get onboard in R&I initiatives because they have closer relations to SMEs within their country.
- Organise 'cluster' meetings, where projects across the R&I spectrum exchange results. Such cluster meetings could be focused on a specific topic (e.g. 6G radio versus 6G network architecture).
- Attempts should be made to match large National 6G Initiatives with initiatives in 'widening' countries (i.e. Bulgaria, Croatia, Cyprus, Czechia, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia, and Slovenia). Collaboration should be established per university / company and not for a complete National 6G Initiative.

The results presented in **Annex 1** can also be used to analyse specific topics of common interest between different National 6G Initiatives. Such analysis is left to bilateral collaboration between National 6G Initiatives. One successful example of such bilateral collaboration is the work on 6G non-terrestrial networks for which a 6G-Sky consortium has been formed which is applying for Celtic funding from a number of national governments. However, it is important to note that Celtic funding is not available in all countries.

4.7 SNS ICE activities related to Cloud

Cloud-related activities were identified as one of the two most relevant topics for establishing collaboration within Europe. In addition to providing an overview and comparison of ongoing activities of primarily European initiatives addressing cloud (see section 3.2), SNS ICE also participated in cloud-related events and activities. One of these activities was the participation in a SNS OPS workshop on Services/Cloud related to the SNS Work Programme (see section 4.5.5). Another activity is the participation in the SNS JU Policy WG on 3C Networks (see section 3.2.9). Two other activities are described within this section 4.7.

4.7.1 Debriefing meeting 6G-IA Cloud and Service Provision workshop

On November 21st, 2024, a debriefing meeting on the 6G-IA Cloud and Service Provision workshop was held. Alexandros Kaloxylou provided feedback on what had happened at the workshop on Services/Cloud in April 2024 and what was done in follow up of this workshop.

The workshop had led to a proposed topic on the SNS R&I Work Programme 2025. A Stream-C call was added to the work programme with the following goals:

- Develop a 6G Service Platform (both network services and user services) and Telco Edge Cloud, including Far Edge and Near Edge integration, leveraging and influencing Open-Source developments.
- Develop 6G telco cloud solutions considering 6G technologies, features, and components at system or sub-system level.
- Target impact in standardization and eventually adoption at the market level.
- Efficiently support advanced 6G applications and use cases not already supported by current 5G and 5G Advanced systems while contributing to core KVI's, notably sustainability.
- Cloud native management of the platform and its telco applications.
- The platform should support AI native solutions.

Target is a single project of 15 MEuro. The proposal was submitted for consultation to 6G-IA members, as part of an overall consultation of the SNS R&I work programme, with in general positive feedback.

Discussions were also held with the IPCEI-CIS programme on cloud and with DG-CNECT on 3G Networking. Note that DG-CNECT is also working on a draft proposal on Telco Edge Cloud deployments and 3C Networks within the context of Horizon Europe Cluster 4 Digital topics.

4.7.2 Workshop of the European Alliance for Industrial Data, Edge, and Cloud

On December 10th 2024, the Data, Edge and Cloud Alliance (see Section 3.2.2) organised a Meeting & Forum in Brussels (snapshot provided in Figure 16). The meeting was a combination of a Data, Edge and Cloud Alliance General Assembly for members of the Alliance and a more open Forum. Some interesting presentations related to cloud, AI and related EU policy.

- Manuel Mateo Goyet (acting head of unit CNECT.E2 Cloud & Software) presented an Overview of Next College Policy Directions (related to cloud). One aspect mentioned was the Data Act which will enter into application 12 September 2025. The Data act will combat current hurdles to switching between cloud providers: “In the European cloud market of the future, providers will compete on performance, innovation, and price, but no longer on practices of locking in their customers.” There are provisions on Free switching (gradual withdrawal of switching charges), Fast switching (minimum requirements for cloud contracts), and Fluid switching (open interfaces, functional equivalence standards, open interoperability interfaces).
- Odysseas Pyrovolakis (CNECT.E2) presented more details on how the Data Act will achieve interoperability of data processing services. A central EU standards repository will be created for the interoperability of data processing services. Both harmonised standards and/or common specifications can be published in this repository. A study has been commissioned (September 2024 – August 2025) to support the identification of the first set of standards and specifications to be referenced in the repository and to operationalize the repository.
- Ernst Stöckl-Pukall (German Bundes Ministry of Economic Affairs) presented a new initiative 8ra “Cloud-Edge Continuum” initiative as an outcome of IPCEI CIS. The objective of 8ra is to create a multi-provider Cloud-Edge. Technologies developed in the 8ra initiative should be the technological basis for two new IPCEI proposals: IPCEI AI - on decentralized and federated infrastructure for Artificial Intelligence and Services, and IPCEI ECI – on deploying large-scale decentralized and federated Edge Computing Infrastructure and Services.
- Matthias Kuom (DLR) presented the Cisero project¹² as a support action for the IPCEI-CIS and 8ra. This support action is of interest to collaborate with from SNS ICE or its successor SNS CO-OP.
- Pearse O’Donohue (Director, Future Networks, DG CONNECT) presented the future direction of EU cloud policy. There is now a new commission in place. Henna Virkkunen will be executive vice-president for Tech sovereignty, security and democracy. Each of the commissioners have obtained a mission letter. Important for the EU cloud policy is also the Draghi report on European Competitiveness [72]. In the Draghi report: “Given the dominance of US providers the EU must find a middle way between promoting its domestic cloud industry and ensuring access to technologies it needs. It is too late for the EU to try to develop systematic challengers to the major US cloud providers (...). For reason of European sovereignty, the EU should ensure that it has a competitive domestic industry that can meet the demand for ‘sovereign cloud’ solutions”. In the mission brief for Commissioner Virkkunen we see e.g. the following goals: reaching Europe’s 2030 Digital Decade targets, Boosting AI innovation, develop and EU Cloud and AI Development Act, and develop a single EU-wide cloud policy for public administrations and public procurement. A new Digital Networks Act should to help boost secure high-speed broadband, both fixed and wireless, incentivizing and encouraging investments in digital infrastructure, taking into account responses to the Commission’s White Paper of February 2024 [2].

¹² <https://www.cisero-project.eu/>



Figure 16: Pearse O'Donohue (Director Future Networks, DG CONNECT) presenting at the Forum.

5 Conclusions and recommendations

SNS ICE has previously reported in Deliverable 2.1 [1] a range of topics addressed by European R&I initiatives and has identified two topics as specifically important for European 6G R&I; 1) creating synergies and enhancing collaborations with European National initiatives and 2) creation of a telco-cloud as proposed in the EU whitepaper “How to master Europe’s digital infrastructure needs?”.

Several activities are organized by SNS ICE that focus on the collaboration between the national 6G initiatives. Although all national 6G initiatives have a common goal to achieve European leadership in 6G, they are all organised differently. The structures of many national 6G initiatives do not allow the flexibility to adapt their work programme on e.g. a yearly basis to achieve synergy with other programmes. However, the work programme of the SNS JU is revised every year, which presents an opportunity to have topics included in the programme that are not well addressed within the national 6G initiatives. The following topics have been identified as potential candidates and SNS ICE recommends that these potential synergies be investigated within the context of formulating the SNS Work Programme 2026:

- o Security - may not be a specific call on security, but security by design in different topics
- o Spectrum and network sharing
- o Services
- o Intelligent agents

Another SNS ICE activity targeting national 6G initiatives is the initiation and support of regular online meetings between the national 6G initiatives. These online meetings are used to e.g. exchange information, organise webinars on topics of common interest or identify bilateral collaboration possibilities. It is recommended that these activities be continued within the SNS CO-OP project, the follow up project of SNS ICE. It is furthermore recommended to include more members from other European countries that are active in 6G R&I, such as the UK.

SNS ICE also contributes its efforts towards the Member State Initiative Report [15] which focuses on the smaller R&I activities that are being carried out within Europe on beyond 5G and 6G. A continuation of this report is one way to ensure that countries where no national initiative is present are able to participate in collaborative research on 6G.

The importance of the cloudification of telecommunication networks and the disaggregated 6G cloud architecture have been consistently highlighted, e.g., by the European Commission and the 6G-IA, and are considered major topics for the European digital sovereignty. In this deliverable, we provided an overview of primarily European activities that are addressing cloud and an analysis on the topics that each activity addresses. This provides a better understanding to the research landscape around cloud. Moreover, to stimulate the European sovereignty, three necessities have been identified, namely funding, standardisation and regulation. Different steps have been taken to address these necessities. In particular, funding has been addressed in the draft SNS Work Programme 2026, the Horizon Europe Cluster 4 call and IPCEI-CIS. Regarding standardisation, it is important to keep the efforts to ensure the inclusion of compute-as-a-service in the 3GPP use cases for 6G. Moreover, regulation is addressed by the SNS JU Policy WG, which aims to align the SNS Work Programme and influence the policy of the European Commission. Furthermore, an analysis on different ongoing cloud activities has been performed, which revealed that some activities are addressing cloud from an IT perspective, whereas other activities from a telco cloud perspective. Although these activities address different requirements, synergies between the activities may be beneficial.

SNS ICE started in January 2023 as the ambassador of the SNS JU and has done important work in ensuring a consolidated 6G ecosystem. One of the biggest wins during this period has been the excellent work done on consolidating the European input on 6G use cases, which were subsequently presented at the 3GPP SA1 workshop on 6G use cases held in Rotterdam in May 2024. Several efforts were taken afterwards to promote this consolidated view at multiple conferences and events. As standardisation forms an integral part of the 6G

technology development and has also been identified as a key activity in many national initiatives, it would be good to continue coordinating standardisation efforts across all European R&I activities. However, it is also important to recognize that it will become increasingly difficult to coordinate the content of standardisation input across all R&I activities as the business interests of individual companies become more prevalent over time as the 6G work takes off. However, in specific projects with a common goal, such a coordinated input between multiple parties should still be possible. Another avenue for consolidated input is the alignment on the importance of addressing Key Values (KV) and Key Value Indicators (KVI) in standardisation.

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Annex 1: Results of questionnaire on National 6G Initiatives

Topic	Germany	Finland (6GFlagship)	France (PEPR)	Netherlands (FNS)	Italy (Restart)	Sweden	Ireland (Connect)
Further evolutions of the SBA	***	***	***	***	***	**	*
Service and Resource orchestration and management	***	***	***	***	***	***	***
Native AI and end-to-end integration for telecommunications	***	***	-	***	***	*	***
Cloud continuum	***	***	***	***	***	**	***
Improve data plane performance/new data transfer paradigms	***		***	***	**	?	**
Energy efficient enablers	***	***	***	***	**	***	***
Digital network twinning for 6G networks	***	***	***	***	***	?	***
Deterministic networking	***	***	***	**	*	?	**
Network exposure to vertical application developers	***	***	-	***	***	**	**
Other topics related to 6G architecture	***		-	***		*	*
Terahertz Communications and Ultra-Massive MIMO	***	***	***	***	***	***	**
Joint communication and sensing	***	***	***	***	***	**	***
New waveforms, random and multiple access schemes, Enhanced modulation and coding	***	***	***	*	**	**	***
Wireless edge caching	***	***	***	**	*	***	*
Human-friendly radio systems (new antenna design, minimize EMF exposure to humans, energy efficient,...)	?	***	***	***	***	***	**
Spectrum refarming and re-utilization	***	***	-	*	**	**	*
Further evolution of wireless systems up to mmWave	***	***	***	***	***	***	***
Seamless integration of multiple frequency bands	***	***	***	*	*	**	*
AI/ML for the radio physical layer	***	***	***	***	**	*	***
Other topics on RAN	?		-	***	***	*	***
Flexible capacity scaling for long-haul and backhaul	*	***	-	***	**	**	**
Novel switching optical architectures and routing protocols	***	-	***	*	***	*	**
Co-existence of fronthaul and backhaul - support end-to-end all optical networks	?	-	***		***	**	***
Light communication (e.g., LED, FSO, Li-Fi, OCC, Fi-Wi)	*	***	***	***	*	*	*



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NTN for 6G networks	***	***	***	**	***	**	-
Unified NTN service provision	***	-	***	**	***	**	-
3D networking	***	***	***	***		?	-
New IoT components and devices	***	***	***		*	***	***
Short range communication protocols	*	***	-		*	?	*
Future Emerging Technologies (e.g., nano-things networking, troposphere networking,...)	***		-		*	**	*
Low energy communication solutions	***	***	***	*	**	***	**
Other topics on network Infrastructure and devices			-	**		*	**
Human-centric methods for privacy and confidentiality	?		***		*	**	***
zero-touch integrated security deployment	*	***	***	**	**	?	**
Physical layer security	***	***	***		***	**	**
Holistic security frameworks and enablers	***		***	**	***	*	*
Service lifecycle management		***	***	***	*	**	-
Other topics related to security and/or service provision	**		-	***		*	**
Microelectronics solutions for 6G networks	***	***	-	***	*	***	**
Sustainability solutions	**	***	***		**	***	***
AI solutions (please indicate their applicability based on network domain e.g., RAN, transport, core, OSS)	***	***	***	***	***	**	***
Development of 6G experimentation platforms	***	***	***	***	***	**	***
Trials with verticals	-	***	-	****	**	**	**
Other topics on any 6G aspect	***		-	***	***	*	*