

# 6G Research & Innovation Activities in Europe: An Overview of EU & Nationally funded Programmes

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**Abstract**—The first 6G networks are expected to be deployed around 2030, and the relevant Research and Innovation (R&I) activities in Europe are well underway. Several 6G R&I funding programmes are ongoing, both on national level and pan-European, creating a complex ecosystem, which, however, offers significant collaboration opportunities. This paper provides an overview of major national 6G initiatives in EU member states. These major national initiatives, with budgets of hundreds of M€ are found in the Netherlands, Spain, Italy, France, Finland, and Germany. For each of these national initiatives information on budget, timing and structure is provided. The paper also presents an overview of the topics addressed in these national 6G initiatives. Additional 6G R&I activities in Europe are identified for the UK, Ireland, Norway, Belgium and Portugal, while an overview of the research topics addressed in the pan-EU collaborative projects of the SNS JU, is also provided.

**Keywords**—6G, Europe, Research & Innovation, Nationally funded Programmes

## I. INTRODUCTION

6G is expected to bring a new technological era in which billions of devices, humans, robots, connected vehicles and more will exchange zettabytes of digital information, offering novel Artificial Intelligence (AI) enabled services and forming a self-contained human and machine-centric ecosystem. As such, 6G has attracted the research interests of multiple nations, and academic, research and industrial institutions around the world, attempting to define its architecture, key enabling technologies and targeted Key Performance Indicators (KPIs).

Especially in Europe, there are several National Initiatives on Member-State level that have funded multiple 6G Research and Innovation (R&I) programmes which explore various research topics and technologies relevant to 6G and have set clear goals for their initial achievements within the next 5 years. Besides the National Initiative (NI) programmes, the European Union, in collaboration with the EU private sector (Industry, SMEs, Academia), has launched in November 2021 a collaborative research program called Smart Networks and Services Joint Undertaking (SNS-JU) [1] to address all relevant 6G research areas with a total funding of €1.8 billion for the period 2021-27. The SNS-JU has commenced its operation with the funding of a first set of 35 collaborative EU projects since 2023, while another 28 projects will begin their operations within 2024.

With all these EU collaborative and nationally funded 6G projects, it becomes important to understand the focus of each National Initiative, the technologies that each programme prioritizes, the similarities and differences in their approach and the alignment of their roadmap with the EU collaborative R&I activities within the SNS-JU. Such an analysis, which effectively draws the EU landscape of 6G R&I activities, is presented in this paper based on the work of the SNS JU funded SNS ICE project [2], which is the de facto ambassador of the SNS JU programme tasked with the monitoring, reporting and promotion of relevant SNS JU activities to the world. The SNS ICE research presented in this paper comprises a comparative study of seven of the largest European National Initiatives with regards to the importance and prioritization that they give to 14 key 6G research topics, based on interviews performed with each of them from SNS ICE partners. The selected research topics have been inspired by the SNS JU Work Programme. More high-level information is provided about five additional national programmes, while an overview of the SNS JU programme focus with regards to key 6G aspects is also provided within this work. The full SNS ICE study can be found in [3].

The rest of this article is structured as follows: Section II provides key information about the selected seven NIs and the research topics they prioritize and offers an aggregated view of the EU NI landscape in a table format. Section III gives a shorter overview of the other five 6G R&I activities that are ongoing in Europe. Section IV describes to the prioritization of research topics within the SNS JU and respective actions to increase collaboration between SNS and national initiatives. Finally section V provides conclusions and describes a way forward.

## II. 6G R&I ACTIVITIES IN MAJOR EU MEMBER STATES

This section focuses on initiatives that are funded by the national governments of EU Member States. Large national initiatives exist in several European countries such as the Netherlands, Spain, Italy, France, Finland, and Germany, with budgets of hundreds of M€. These initiatives are targeted due to their size which makes them comparable to the budget of the SNS-JU. Note furthermore that this overview focuses on R&I funding that has a similar scope as the Horizon Europe SNS programme.

First information on the different national initiatives was collected based on publicly available presentations, websites, et cetera. As the level of detail and type of information publicly available differ significantly between the different national initiatives, the SNS ICE partners organised structured interviews, where all the national initiatives were asked the same set of questions. Finally, to ensure that the information provided is correct, the national initiatives were asked to review the section describing their respective programme.

The map in figure 1 shows the selected national 6G initiatives included in this study. For each of the national initiatives information is provided on name, public funding from the national government, and start and end date.

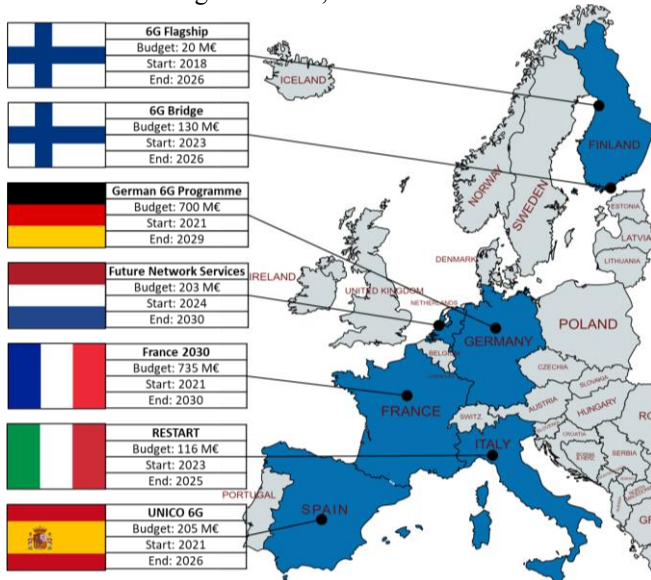


Figure 1: Overview of the 7 selected national 6G initiatives

In the remaining parts of this section more information is provided for each of these national initiatives.

#### A. 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 [4]. 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 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 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.

#### B. 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 [5]. 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 TRL levels 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 levels 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 levels 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 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’ve received from the national programme, after excluding the funding they’ve outsourced.

### C. Italy

The national initiative from Italy is called RESTART: ‘RESearch and innovation on future Telecommunications systems and networks, to make Italy more smART’ [6]. 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.

### D. 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 [7]. 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;
- 5G acceleration of deployment and vertical services offer;
- 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.

### E. Finland (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 [8]. 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.

#### F. Finland (6G Flagship)

6G Flagship is a part of the Finnish government’s national research spearhead programme from 2018 to 2026 [9]. 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
<b>Wireless connectivity</b>	Advanced networking technologies
	Wireless access technologies
	Massive wireless automation
<b>Devices and circuit technology</b>	Radio platforms
	Radio hardware
	Experiments and proofs of concept
<b>Distributed intelligence</b>	Computing on the edge-to-cloud continuum
	Distributed AI
	Multimodal sensing and modelling
<b>Human-centric wireless services</b>	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.

#### G. 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 [10]. 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 follow (status September 2023):

- 2021 – 2025, 6G Platform Germany
- 2021 – 2025, Four 6G Research Hubs
- 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€.

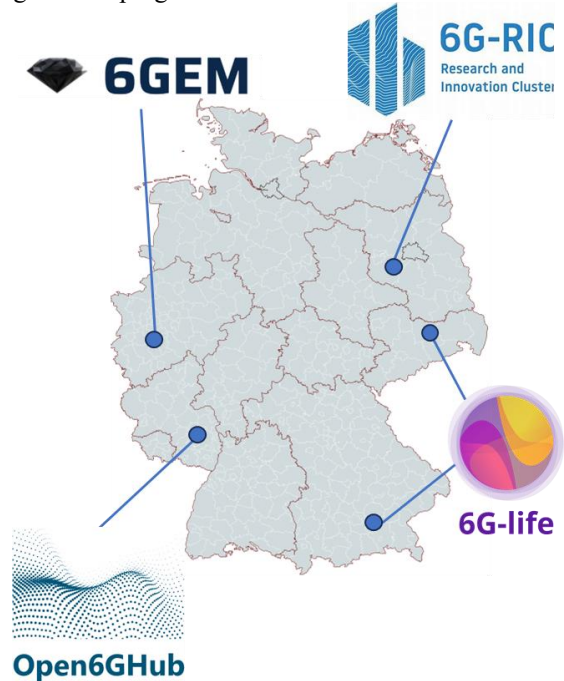


Figure 2: The four German research hubs

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).



Table 2: Overview of relative importance scores from the different national initiatives

Topic	Relative importance						
	Netherlands	Spain	Italy	France	6G Bridge Finland	6G Flagship Finland	Germany
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	**	-	*	**	*	***	**

#### H. Overview of the topics covered by the different national initiatives

Table 2 provides an overview of the topics each of the national initiatives covers. To facilitate comparison between activities in the presented NIs and the SNS Programme, a categorization of activities inspired by the SNS work programme has been used. Each of the NIs were asked to rate to what extent the different topics are covered in their programme using a star rating with the following classification:

- \*\*\* : Main focus area
- \*\* : Relevant area
- \* : Also addressed
- - : Not addressed.

Note that Human Capital is not included as a topic in the SNS programmes, however, it is a part of several National initiatives. It relates to strengthening the academia to attract more students and researchers, and/or promotion of spin-off activities and start-up companies.

It is interesting to note that based on the expressed priorities of the National Initiatives, System architecture, Edge and Ubiquitous computing and Radio technology and signal processing seem to attract most of the interest. Moreover, all national programmes seem to pay special attention to creating their own Experimental infrastructure and performing Trials & Pilots.

### III. ADDITIONAL R&I ACTIVITIES IN EUROPE

In addition to the major initiatives described in the previous section, other EU Member States (MS) also run their own R&I programs towards the development of 6G, with the support of either EU's Recovery and/or national funds. This section focuses on a subset of those national programs, namely, those in the UK, Ireland, Norway, Belgium, and Portugal. These initiatives are included in the yearly report entitled '5G, beyond

5G, and 6G Activities Promoted by Member States' (see [11] for the latest release). However, the scope of this report, which is produced by the Member State Initiatives Subgroup of the 6G-IA Vision and Societal Challenges Working Group, is broader since, in addition to national R&D programmes, it also keeps track of e.g., the elaboration of strategic documents (National Plans, White Books), activities in clusters or spectrum allocation activities.

Research and development on 5G and 6G wireless technology in the UK includes, on the one hand, 23 M€ funding for three top UK universities (York, Bristol, Surrey) to team up with major telecom companies, including Nokia, Ericsson, and Samsung; and, on the other hand, 80 M€ for a UK Telecoms Lab aimed to perform research and testing activities on security, resilience and performance of 5/6G network technology. Besides, the UK Space Agency has made a substantial investment (50 M€) in R&D projects to support satellite communications. This encompasses their integration with 5G (terrestrial) systems for an enhanced connectivity of people and machines.

The Science Foundation Ireland has established a network of SFI Research Centres focusing on key research areas. CONNECT brings together world-class expertise from ten academic institutes to create a one-stop-shop for telecommunications research, development and innovation. It engages with over 40 companies including large multinationals, SMEs and start-ups.

In Norway, two publicly funded research programs have led to 5G-6G relevant research: ICTplus, and National Research Infrastructure. In both cases, the public body in charge is the Norwegian Research Council. Besides, the Nordic-Baltic 5G monitoring tool project will contribute to the development of a more integrated, connected, and inclusive Nordic Region. Its goal is also to promote cross-border collaboration in the industry verticals. The project is financed by The Nordic Council of Ministers.

In order to contribute to research on future mobile technologies, the federal government of **Belgium** has allocated a budget of 1.5 M€ to support research projects on future 6G mobile technologies. It is part of the “Telecom to the next level – towards sustainable and innovative solutions” programme of the recovery and transition plan. Belgium, has also launched its DEFence-related Research Action (DEFRA) program. It covers 4 themes with an indicative budget of 1.6 M€ each. One theme is related to 5/6G for military, security and crisis applications.

Finally, the **Portuguese** Recovery Plan (Next Generation EU) comprises three dimensions or pillars, one of these being Digital Transition, with an overall investment of 2.5 B€. It aims to promote the adoption of technologies, including 5G and beyond, that foster the digital revolution in several areas.

#### IV. EU COLLABORATIVE PROJECTS ON 6G

As mentioned before, the SNS JU programme has also launched its R&I activities since 2023 with the funding of 35 collaborative projects (33 R&I projects and 2 Coordination and Support Actions - CSA). These projects address a wide variety of research topics, ensuring Europe's continuous leadership in the telecom sector. The SNS OPS CSA project conducted a survey among the 33 R&I Phase 1 SNS JU projects to better understand their respective focus and to extract data and analytics with regards to technologies and aspects prioritized during this first phase of the SNS JU. This SNS OPS survey which is available in [12], also provides insights into the number of projects addressing a sub-set of the previously discussed research topics as depicted in Figure 3.

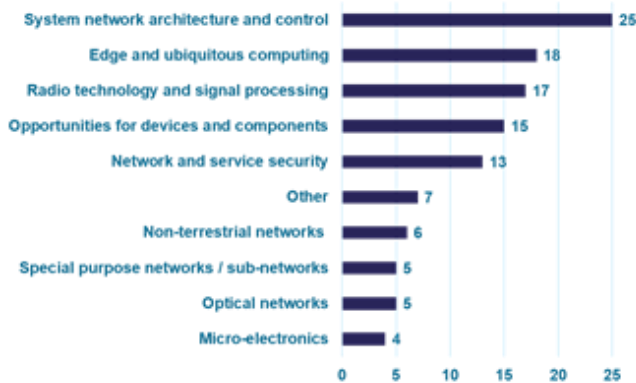


Figure 3: Prioritization of Research Topics by SNS Phase 1 projects

Based on the collected data it can be observed that system architecture, edge and ubiquitous computing, novel radio technology and dedicated devices and components, are prioritized during the first phase of SNS JU. Nonetheless, a broad coverage of research topics is achieved, nicely matching the National Initiative programmes research directions. It has to be noted, that SNS JU launches a new call for R&I actions every year adjusting the targeted topics, to ensure a good coverage of all prioritized research topics, and as such the result of the analysis presented in Figure 3 will be adapted on an annual basis.

#### V. CONCLUSIONS AND WAY FORWARD

Based on the analysis presented in this paper it can be concluded that there is a significant amount of 6G R&I activities that are not funded by the EU but by individual member states. The overall public funding of these member states surpasses the

900 M€ funding which is the public (EU) side contribution to the 1.8 B€ budget of the Horizon Europe SNS JU. Additionally, the presented analysis indicates that there is an alignment on addressed research topics between the NIs and the collaborative SNS-JU projects, as well as sufficient complementarity to allow for the coverage of a broad spectrum of novel technologies which will strengthen EU's role in the global 6G stage.

All of the presented national initiatives have indicated that they support the common goal of a leadership role for Europe in the global 6G R&I landscape. In order to achieve European leadership, a collaboration between the NIs and the SNS JU is deemed beneficial and may lead to an enhanced EU role in the upcoming 6G standardization activities. The SNS ICE project, as the SNS JU ambassador, aims to facilitate that collaboration.

Some specific collaboration actions have been proposed in discussions between SNS ICE, and representatives of national initiatives and other SNS projects. One proposal is to aim for a joint European R&I input towards 3GPP e.g., to influence SA1's work on 6G use cases definition. Other collaboration actions aim to establish communication links with and between the national initiatives and the identification of additional topics for joint or bilateral R&I activities.

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