ANNEX II TO DECISION No 13/2021 OF THE GOVERNING BOARD OF SMART NETWORKS AND SERVICES JOINT UNDERTAKING

6GSNS

**ANNEX 2 to the SNS Work Programme 2021-2022 –
First phase of SNS R&I Work Programme**

Context and Objectives

This first Work Programme (WP) of the Smart Network and Services (SNS) Partnership[1] supports the following Key Strategic Orientations (KSO), as outlined in the Horizon Europe (HE) Strategic Plan:

- **KSO A**, 'Promoting an open strategic autonomy by leading the development of key digital, enabling and emerging technologies, sectors and value chains to accelerate and steer the digital and green transitions through human-centred technologies and innovations.'
- **KSO C**, 'Making Europe the first digitally led circular, climate-neutral and sustainable economy through the transformation of its mobility, energy, construction and production systems

In addition, the Work Programme is expected to contribute to the following goal:

- **Foster Europe's technological leadership** in digital technologies and in future emerging enabling technologies, by strengthening European capacities in key parts of digital and future supply chains, allowing agile responses to urgent needs, and by investing in early discovery and industrial uptake of new technologies.

The SNS Partnership targets reinforced European leadership in the development and deployment of next generation network technologies, connected devices and services, while accelerating the digitalisation of European industry and public administrations. It aims at positioning Europe as a lead market and positively impact the citizen's quality of life, by supporting key Sustainable Development Goals (SDGs), boosting the European data economy, and contributing to European technological sovereignty in relevant critical supply chains.

Within this broader context, the first SNS WP is expected to progress towards the technological and business realisation of the 6G vision developed notably under the 5G Infrastructure PPP and targeting massive digitisation of societal and business processes through intelligent connectivity across the human, physical and digital world. This covers several related objectives, and in particular:
- Moving beyond a simple increase in speed or performance of connectivity platforms, bringing unique new service capabilities with wider economic implications. It requires capabilities for completely new services and applications, aligned with sustainability targets and a human-centric approach. This will eventually lead to 6G solutions, like the "Internet of Senses", realising a fusion between the

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communication and sensing environment, massively scalable immersive environments, like XR/VR, digital twins, and holographic communication.

- Supporting key United Nations Sustainable Development Goals (SDGs)[2], with SNS aiming to directly to align to:

- **SDG 8**: Promote sustained, inclusive, and sustainable economic growth: achieve higher levels of economic productivity through diversification, technological upgrading, and innovation.
- **SDG 9**: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation, upgrade infrastructure and retrofit industries to make them sustainable with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes.
- **SDG 11**: Make cities and human settlements inclusive, safe, resilient, and sustainable
- **SDG13**: Climate Action: Support smart low carbon lifestyles, monitoring emissions, and shaping demand in transport and energy, enabling resilient mission critical communications in extreme weather (vertical markets: transport, health, and public safety)

This alignment serves as an example to proposers. It is expected that proposals will also identify any other SDG that their work will contribute to. In addition, complementary societal issues, such as ethical issues in the context of privacy or Electric and Magnetic Fields (EMF) awareness and reduction, are targets of the SNS WP.

Supporting Key Societal Value indicators (KVI) such as safety, security, trustworthiness, inclusiveness, and sustainability are described in further detail below. Several factors form the basis for new research and innovation targets underpinning the evolution of 5G and the design of 6G networks. Some of them include full industry digitalisation, supply chain resilience, and the need to address European and global societal challenges.

Moreover, the SNS WP targets a strong European impact at future downstream 6G standardisation stages, including a Europe wide consensus of 6G Key Performance Indicators (KPIs) that will frame future developments. Additionally, it targets the integration of concepts and technologies originating from the Cloud/IT environments to support massive device (IoT) connectivity and ultra-reliable communications and services on top of enhanced mobile broadband services. This is an important target towards a complete value chain to serve an IoT device-connectivity-service platform where Europe can successfully compete.

The stimulation of strategic alliances is a key objective, with vertical sectors to build and offer powerful and persuasive Business to Business (B2B) and Business to Consumer (B2C) propositions. This should leverage upon general, local, regional, or even universal and global smart interconnected public and private networks and services. In this WP, the industry is described in terms of vertical sectors. A strategic goal of the SNS Partnership is to empower many vertical domains further beyond current 5G capabilities. Participation and contribution of these actors to the SNS WP are considered important, both to drive the requirements and to validate the technologies in specific business contexts.

The SNS WP aims to contribute to several European policies[3], and notably:

- Green Deal[4]

- Resilient Communication Privacy via Developing Proper Security Strategies [5]

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2 http://www.un.org/sustainabledevelopment/sustainable-development-goals/
3 https://digital-strategy.ec.europa.eu/en/policies
4 https://ec.europa.eu/info/sites/default/files/european-green-deal-communication_en.pdf
5 https://digital-strategy.ec.europa.eu/en/policies/cybersecurity-act

- Artificial Intelligence (AI) [6] [7] [8]

- Data & Cloud Computing

- Blockchain Technology

- High Performance Computing (HPC)

- Internet of Things [9]

- Microelectronic components

To that end, the SNS Partnership will put in place appropriate mechanisms to allow the close collaboration with other relevant partnerships, notably in the areas of HPC, micro-electronics, photonics, AI and data analytics and Connected, Cooperative and Automated Mobility (CCAM) as appropriate. Relevant proposals in these domains are expected to support these goals.

Additional goals of the SNS WP are to

- Develop strategies and technologies for the integration of future connectivity and service platforms into larger globally applicable infrastructures, whilst preserving European competitiveness and sovereignty.

- Define trust, security and communication privacy enhancing technologies, process and architectures that will be required for massively heterogeneous, virtualised and software platforms of the future.

- Bring new actors from, and beyond the verticals. Contributions from industry, Research and Technology Organizations (RTO), academics and Small and Medium-sized Enterprises (SMEs) actors in the connectivity, IoT and cloud/IT domains are expected to be complemented, where applicable, by adequate participation of the micro-electronics industry from the onset of the partnership, in view of their potential impacts at downstream standardisation level.

- Provide a stable experimental framework towards minimising risks and validating core technologies.

- Provide a unified consensus framework promoting a European approach towards 6G, facilitating international cooperation and placing Europe on par with other regions having started significant 6G initiatives (USA, China, Republic of Korea, Japan).

The SNS WP hence offers opportunities to European stakeholders in industry, research and academia to build innovation capabilities to achieve a leading position in the standardization process (e.g., 3GPP, ETSI, and similar organisations addressing the broader scope of Smart Systems and Networks), securing a leading position for Europe in the global ICT market, over the coming 8-10 years.

The scope of the SNS WP considers the broader value chain. The NetWorld Europe Strategic Research and Innovation Agenda (SRIA) [10] and the related implementation Annex D [11] are the foundation for the definition of the R&I technical themes of the SNS WP. The SRIA was developed by R&I stakeholders under coordination from NetWorld Europe, including contributions from the 6G Smart Networks and Services Industry Association (6G-IA), the wider cloud (NESSI and CISPE.cloud), IoT and edge (AIOTI) and Satellite Communications (SATCOM) communities. It indicates the core technological topics to be addressed by the SNS Partnership underpinning the higher-level objectives and the implementation of the 6G roadmap.

The proposed WP includes the following four complementary streams:

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6 https://digital-strategy.ec.europa.eu/en/policies/artificial-intelligence
7 https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=75787
8 https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai
9 https://digital-strategy.ec.europa.eu/en/policies/iot-policy
10 https://bscw.5g-ppp.eu/pub/bscw.cgi/d367342/Networld2020%20SRIA%202020%20Final%20Version%202.2%20.pdf
11 https://bscw.5g-ppp.eu/pub/bscw.cgi/d392313/Annex%20v2.3%20-%20Public.pdf

- **Stream A:** Targets the development of smart communication components, systems, and networks following the evolution of 5G systems. It follows an evolutionary path towards the development of 6G networks, relying on the development of an intermediate technology point. The proposed research topics are complementary and altogether support a complete system view.

- **Stream B:** Covers research for revolutionary technology advancements, in preparation for 6G and revolutionary advancements of IoT, devices and software. This Stream targets Low Technology Readiness Level (TRL) technologies that are expected to deliver innovative solutions towards real life networks in the long term..

- **Stream C:** Focuses on SNS Enablers and Proof of Concepts (PoCs) used to develop experimental infrastructure(s), ideally aiming at being used during later phases of the SNS.

- **Stream D:** Aims at large-scale SNS trials and pilots with verticals, including the required infrastructure. The aim is to explore and demonstrate technologies and advanced applications and services in vertical sectors. Phase 1 Stream D projects should incorporate technologies that currently appear as key enablers for 6G networks, e.g., AI/ML, cybersecurity, high performance computing, advanced IoT solutions, etc.. During the subsequent SNS phases, Stream D infrastructures will mostly rely on SNS phase 1 technologies and especially the infrastructures to be developed from Stream C projects. The goal is to gradually incorporate innovative 6G functionalities.

This SNS Phase 1 is expected to build upon the outcomes of 5G-PPP projects, as well as to capitalize on the results from other instruments and initiatives (e.g., undertaken in Member States, Horizon 2020, or other activities that follow open principles, as for example Open RAN, etc). The SNS roadmap (Figure 1) illustrates the phases of the four streams. The SNS roadmap is expected to be further updated considering the SNS objectives and the key achievements from phase 1 projects.
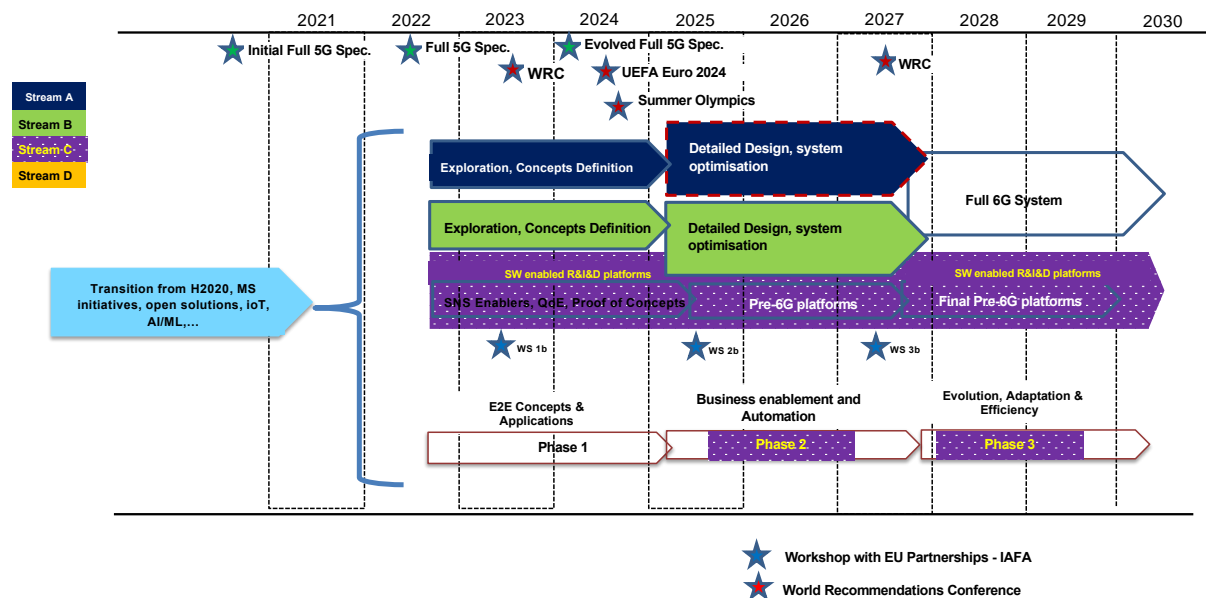

Figure 1: SNS Roadmap

Figure 2 illustrates the phases of the SNS JU[12]. It also presents how the outcome of each Stream is combined with other Streams' activities and results during the following SNS phases. Thus, it is envisioned that complementary results from the Streams may be re-used in subsequent phases.

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12 The figure will be further updated/upgraded before the release of later SNS WP's

The arrows illustrate how the outcomes of projects in Phase 1 could be used in Phase 2, and then likewise from Phase 2 to Phase 3. More specifically,

1. Stream C Experimental Infrastructure technologies are expected to serve as the basis for the subsequent phase Stream D Vertical Pilot projects.

2. 6G solutions and potential PoCs, to be developed in Stream A and B projects, are expected to contribute to the Experimental Infrastructure projects (Stream C) and Vertical Pilot projects (Stream D) of subsequent SNS JU phases.

3. Experimental infrastructure Projects (Stream C) and especially Vertical Pilot projects (Stream D) are expected to provide new requirements (e.g., KVIs, KPIs) to Stream A and Stream B projects of subsequent SNS JU phases.

4. The further development of Stream C projects is expected to follow a spiral evolutional approach, subject to the successful delivery of selected projects. The further development of Stream D projects is expected to follow a spiral evolutional approach, subject to the successful delivery of selected projects.
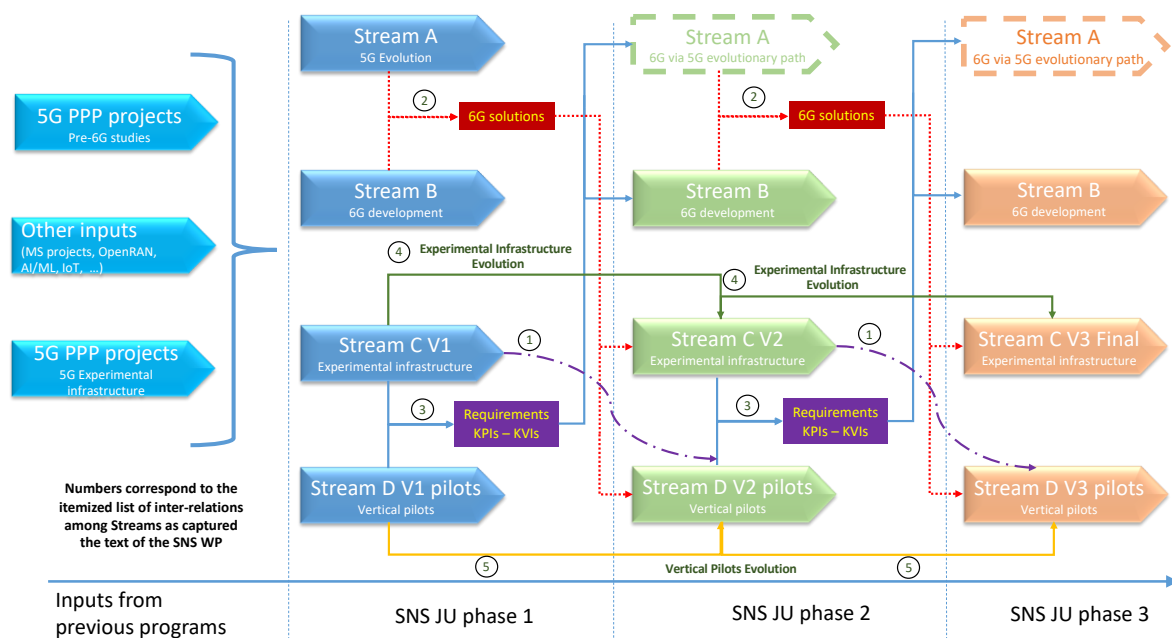

Figure 2: Interlinking of Streams into Phases

The progress in the streams will be evaluated against a well-defined set of 6G KPIs (considering as the baseline NEtWorldEurope's SRIA KPIs, 6G KPIs produced by 5G PPP projects, etc.). In addition, KVIs will show how the SNS projects will provide societal impact to vertical sector applications and to European industrial competitiveness. The indicative list of KVIs illustrated below have been drawn from previous EU projects (e.g., in 5G PPP ICT-52-2020 projects) and is to be adapted to the goals of the SNS projects[13]:

Democracy	Ecosystem	Innovation
Privacy	Sustainability	Safety
Fairness	Business value	Security
Digital inclusion	Economic growth	Regulation
Trust	Open collaboration	Responsibility
	New value chain	Energy consumption

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13 https://www.isitethical.org/key-terms/, and work of Hexa-X, Ziegler & Yrjola - 2020

KVIs may be new to some applicants and should be used alongside KPIs to illustrate project benefits. To demonstrate "security" for example, a project may collect network traffic data (KPIs) and interview vertical sector use case actors, providing metrics and validating the solution in place.

Outcomes of projects funded by Member States are also expected to provide valuable input to SNS JU projects, and vice versa. During the lifetime of the SNS Partnership, and when moving from one phase to the other, the aim is that the competition will remain open in such a way that projects of the previous phase do not have undue access privilege to demonstration and pilot facilities of the next phase.

The strategic and effective operation of the SNS partnership itself is an important condition for meeting Europe's strategic objectives in the field of SNS, which requires long-term commitment from a large set of stakeholders. Where appropriate, proposals should demonstrate that they contribute to SNS through In-kind Contributions to Operational Activities (IKOP) or In-kind Contributions to Additional Activities (IKAA) and foster increased membership of the Private Member of the SNS JU[14].

It should also be highlighted that one of the SNS Programme KPIs is the participation of SMEs at the RIA and IA activities at a level of 20%. It is also important to note that projects of the various Streams will cooperate in the SNS Programme for issues of common interests, ***see call conditions under Appendix 1***

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[14] The private member of the Partnership is the 6G Infrastructure Association, 6G-IA: https://6g-ia.eu/

SNS- Stream A - Smart Communication Components, Systems and Networks for 5G Evolution Systems

Specific Challenges and Objectives

The challenge is to address emerging mid-term requirements, deriving from evolving policy objectives, societal needs, digital business operations, and new application domains, that cannot be supported by existing connectivity and service systems.

A key goal is to prepare for new advanced user services (e.g., immersive communication, holographic telepresence & Augmented Reality / Virtual Reality etc.), as well as new vertical industry challenges (e.g., connected and automated mobility, environment surveillance, personalized medicine, etc.) which require significant improvements from existing connectivity and service platforms.

Another goal is to support the European vision for societal challenges such as digital inclusion and accessibility, unlocking rural economic values and opportunities, under a Green Deal overarching objective (see KVIs explained in the 'Context and Objectives' above). It requires addressing high energy efficiency solutions. It also aims at an open connectivity and service platform evolution with reduced energy consumption and lower operational and ecological costs, able to meet KPI requirements identified in the NetWorld Europe's SRIA for mid-term objectives.

The challenge is hence to develop the technologies supporting these mid-term functional and non-functional properties. It also requires realising seamless and cost-effective integration of multiple enablers from related domains (e.g., HPC, (cyber-)security, AI/ML, IoT) with the objective to prepare strong European industrial positions for the further mid-term evolution of 5G standards expected in upcoming 3GPP Releases and eventually moving towards the 6G era.

It is anticipated that Stream A projects will define and establish system level interfaces to be able to realize a unified vision of pre- 6G systems, with the support of the Coordination and Support Actions (CSAs)..

AI techniques are expected to be widely explored across Stream A projects. The data sets to be used for the training and the evaluation of the mechanisms to be developed are key for open innovation strategies. Such open data sets (e.g., date of release, its scope, and the dimension and diversity of data) will be considered as part of the impact evaluation criteria for relevant projects that aim to explore AI techniques.

SNS-2022-STREAM-A-01-01: Green Radio technology

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

- Technologies for basic building blocks that go beyond the current 5G wireless system specifications, supporting improved wireless communications' efficiency and capabilities in increasingly dense environments and number of end-devices.

- Support for a multitude of services, including further advancements on enhanced Mobile Broadband (eMBB), massive machine type communications (mMTC), Ultra-Reliable Low-Latency communication (URLLC), Vehicle-to-everything (V2X), etc., with significantly more stringent requirements, such as multi-Gbps data throughput, high reliability, and security, as well as high degrees of adaptability, while addressing energy efficiency.

- Identification of technologies, best practices, methods, and tools, for maximising performance vs energy consumption, addressing societal questions, such as EMF impact and urban impact of antennas, especially for city dense environments.

- Support to direct impact in standardization.

Scope

- Signal processing techniques and technologies for evolved Radio Access Network (RAN) systems, also considering the end-devices, operating on relevant frequency ranges (i.e., frequencies both below 6GHz and above 26GHz) and possibly incorporating novel AI/ML techniques where relevant.

- Design and evaluation of advanced solutions focused on the physical layer. Impacts on changes to the higher layers of the RAN system is in scope as well as the impact of current trends (such as cell-free and software-based radio systems, etc.) and of architectural solutions where higher layer protocols are disaggregated and implemented in appropriate (edge) cloud-based solutions. Similarly, the usage of microelectronics technology (e.g., in the domain of hardware acceleration) is also in scope.

- Spectrum re-farming, improvements on millimetre wave technologies including massive and ultra-massive MIMO, unified air interfaces, and continuing improvements on technologies for massive connections (such as random multiple access, broadcast/multicast architectures, and cell free networks). Focus should be on technologies able to smoothly enable and evolve existing systems towards improved energy efficiency, considering aspects such as full-duplex, AI/ML techniques and advanced wireless edge caching.

All the above-mentioned topics should also relate their results in tangible gains on minimizing the required energy for the network operation.

The above topics listed in the scope represent the core focus of SNS-2022-STREAM-A-01-01, without precluding the potential inclusion of other related technologies still contributing to the listed Expected Outcomes.

SNS-2022-STREAM-A-01-02: Ubiquitous Radio Access

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

- Availability of 5G technology and systems economically deployable in low density environments or areas where economic coverage is challenging.

- Deeper integration of terrestrial and Non-Terrestrial Networks (NTN) towards easier operations of multi technology RAN implementations.

- Accelerate 5G deployment and address key societal challenges while creating new market opportunities for the terrestrial and satellite eco-system enabling service provision to vertical industries

Scope

- Provision of connectivity and service access in remote locations, with integration of terrestrial and NTN to provide ubiquitous wide-area wireless access. It covers concepts like native integration of the air and space borne components into beyond 5G systems.

- Highly consolidated NTN architectures such as standalone LEO/MEO/GEO platforms (or interconnected with a second tier) to prove the integration of high TRL NTN system into the 5G-advanced roadmap.

- Improvements of existing air-interfaces to provide ubiquitous connectivity in a heterogeneous environment, where users may access the network through terrestrial and non-terrestrial links, and a reconfigurable radio access network that can be dynamically adjusted to changing conditions and requirements, and ease the co-existence of different services.

This topic should address the improvements of RAN systems considering integrated non-terrestrial component for beyond 5G, and dynamic access methods (such as device to device (D2D)). Going beyond traditional geographical coverage, and reaching towards user-centric communications (e.g., cell-free systems), research is also expected towards the development of radio access management techniques exploring distributed ultra-massive antenna deployment (for both terrestrial and NTN), and addressing challenges such as spectrum re-use and co-existence, possibly incorporating novel AI/ML techniques to manage the complexity of such novel architectures.

The above topics listed in the scope represent the core focus of SNS-2022-STREAM-A-01-02, without precluding the potential inclusion of other related technologies still contributing to the listed Expected Outcomes.

SNS-2022-STREAM-A-01-03: Sustainable Capacity Networks

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

- Improve technologies to scale up network capacity and control latency while at the same time limiting energy consumption, with improved reliability, safeguarding the network infrastructure against data leakage and unexpected service outages (or other form of hazards, natural or man-made) in multi-stakeholder scenarios.

- Enhanced capability transport networks capable to cope with evolving end-user requirements, increasing and denser coverage of mobile for future cellular or cell-free communications.

- Advances in network control, automation, and autonomy, paving the way to truly self-managed networks.

Scope

The scope focuses on new transport requirements addressed by technological advances in optical networks, including increased programmability (and corresponding vertical and horizontal interfaces) and remote configurability at the device level. Different functional splits between baseband and radio units as well as network slicing and call for co-existence of different transport modes on the same transport network.

- Cost-effective high-capacity technologies, developing the coherent optical technologies that will lead to an interoperable low-cost converged packet-optical transport network effectively capable of removing boundaries between different network domains.

- Novel optical transmission and switching schemes and architectures to provide innovation on the forwarding plane and that potentially will lead to the standardization of new semantic descriptions, information models, and routing protocols for management and control, catering to the specificities of evolved optical networks.

- Pervasive telemetry to allow for a more autonomous network operation and optimization, taking energy consumption minimization into account for software-defined environments.

The above topics listed in the scope represent the core focus of SNS-2022-STREAM-A-01-03, without precluding the potential inclusion of other related technologies still contributing to the listed Expected Outcomes.

SNS-2022-STREAM-A-01-04: Evolved Architecture for Global Green Systems

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

- Reduced energy and carbon footprint of the evolved 5G network, through de-carbonisation of the evolved networks and increased renewable penetration capabilities within SNS user "vertical" domains.

- Extension of the 5G Service Based Architecture (SBA) applicability to an extensive value chain covering a holistic system covering data communication, distributed computing, and data storage, extending the communication infrastructure into a sustainable, interconnected, greener end-to-end intercompute system, supporting all types of services and interconnected networks.

Scope

The work focus is on an architectural transformation, targeting energy-efficiency, using the flexibility that the Service-Based Architecture (SBA), introduced in Rel15 (TS23.501), is offering.

- Improved architectures considering all elements of the future SNS systems, from the terminal to the data centre, how these will communicate efficiently with each other and how the overall system will be capable to jointly optimize their energy consumption.

- Extensions of the current SBA focus on the core network control plane, towards a unified coverage of system design and runtime composition/resolution, including multicast/broadcast services, cross-plane (i.e., from user plane to the management planes), and incorporation of new types of compute resources (e.g., at the edge).

- Definition of adequate interfaces for integrating compute, transport and RAN considerations in a globally optimized system.

- Beyond the architectural extensions of the SBA as mentioned above, the work may cover the transport extensions of the underlying infrastructure and the consistency and distribution effects for the involved databases.

- The efficient collection of increasing volumes of data to facilitate the use of AI, expanding on trends considered by standardization organizations (e.g., 3GPP and ETSI), while maintaining the necessary consistency to provide optimized and energy-efficient infrastructures, and enable public and private networks to jointly interconnect and operate towards a common efficiency goal.

The challenges posed by the expected novel services requiring strict timing, fast mobility, and highly dynamic situations (such as trains, moving vehicles, etc.), and by the security aspects of the overall service chains possible to establish with this architecture are in scope. Solutions for bridging the control, management and operational divide that needs to be addressed for seamless operation of joint Public and Non-Public interconnected networks (e.g., campus or emergency service networks, local, regional or even universal and global smart interconnected networks and services) are also in scope. In that evolving context, digital technologies such as Artificial Intelligence, programmable and energy optimized cloud and edge computing solutions may be considered.

The above topics listed in the scope represent the core focus of SNS-2022-STREAM-A-01-04, without precluding the potential inclusion of other related technologies still contributing to the listed Expected Outcomes.

SNS-2022-STREAM-A-01-05: Edge Computing Evolution

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6 million.

Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

- A clear technological strategy for edge integration into a cloud continuum offering opportunities for European cloud/edge technology suppliers and supporting various edge/access integration scenarios, (e.g., NTN).

- Edge architecture and technologies supporting most demanding applications and use cases such as high automation levels for autonomous driving, immersive applications such as digital twins, advanced XR/VR, hologram applications, requiring extremely low latencies and/or very high-capacity justifying edge processing and computing.

- Open, secure, distributed, possibly decentralised, edge computing architectures and implementations optimally integrating heterogeneous communications and networking in edge computing for IoT, with a value chain perspective opening innovative IoT applications and control.

Scope

The work brings virtualization and disaggregation in different segments (home, edge, datacentre, NTN ground and on-board flying nodes), under the scope of multi-access edge computing concepts. The scope is to address functional placement and optimised computing distribution capabilities as a function of requirements emerging from ultra-low latency, ultra-high-capacity immersive applications. Additionally, it may include:

- AI and distributed security to protect transmitted data at the edge computing servers based on ledger or other technologies may be considered.

- The development of the data and control plane techniques required to realize such a multi-edge architecture.

- New IoT device management techniques as needed to operate over distributed architectures for IoT systems based on an open device management ecosystem.

- Novel programming models and engineering practices (e.g., split-computing), preferably applicable to open software environments, enabling the flexible distribution and migration of computation tasks, both horizontally among peer devices, and vertically along the IoT-edge-cloud continuum to enable economic sectors exploiting at the best the potential of the edge computing.

- Optimal deployment of the required data plane paths and control plane elements across a set of distributed physical edge nodes.

- Flexible hardware platforms, and/or programming abstractions (covering individual and aggregate resources) to achieve the benefits for agile, simplified yet automated composition and management of resources, possibly separated in "islands".

- Models for devices interacting with the physical world (sensors and actuators).

- Demonstrate the provision of high-quality services (including reliable Operations Support System (OSS) mechanisms) while executing a very precise-latency or capacity control over massively distributed resources.

- Provide the necessary openness for making edge computing a "service innovation platform" running their own vertical-centric functions with optimised slice distribution and management.

Related work includes data exploitation for easy generation of big data pipelines, supporting increasingly complex/intelligent data processing techniques. To explore the wealth of data expected in new services, the project will need to provide a common, standard dataspace, to be openly offered for future research activities and paving the way towards intelligent infrastructure and service management, including sustainability aspects.

SNS-2022-STREAM-A-01-06: Trustworthy and Reliable End-to-end connectivity Software platforms

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

- Novel technologies/methods for ensuring Trust and Reliability, evolving 5G, in a very distributed multi-stakeholder context, extending the concept of edges from small CPEs and IoT devices to regional datacentres, enabling full control over end-to-endend-to-end data flows and trust on the execution environments.

- Further evolving security of 5G towards the notion of building and maintaining Trust in deployed and interconnected 5G systems and services.

- An open, flexible architecture, for evolved 5G, able to cope with widely distributed, federated, and dynamic systems for data processing, data storage and communication tackling data reliability challenges.

- The outcome should build trust and reliability, significantly advanced beyond the baseline security measures of 5G.

Scope

The work addresses the reliability/trust challenges created by fully virtualized solutions, increased network programmability, extended network exposure and tight integration to service providers and non-public networks spanning the business actors of the value-chain. It includes:

- Secure and reliable technologies for efficient containers and smart and secure container orchestration, with reliable software virtualization, with fast instantiations and mobility support seen as promising primitives for supporting these novel security architectures, and subsequently be transferred to standardization bodies.

- Support of flexible security policies in very distributed (and continuously changing) settings complementing traditional perimeter protection technologies.

- Holistic approaches to reliability, spanning the lifecycle of smart networks and services.

- Novel requirements from challenging verticals, jointly using secure software engineering and operational procedures to manage risks across multiple stakeholders including quantification of security attributes and communication of associated risk for stakeholders.

- Better tools for initial 'security by design' and for creation of "safer" code, collaborative methods, and run-time tools to manage risks, and measures to cope with new developments in areas such as AI.

- Virtualisation of security functions (Protection, detection, remediation) and Exposure and integration of security services (MSSP, NOC-SOC interactions).

- Enablement of service and infrastructure providers (including end-users) to enter into agreements with infrastructure maintainers, based on the capabilities of the SBA-architectures, to provide storage and/or communication of data without the need for all parties to trust each other.

- Adherence with and improvements of efficient data sovereignty strategies in different domains (including bridging public and private networks) by enabling secure applications in different vertical domains should be demonstrated notably through measurable/observable outputs in terms of trust in networked components and subsystems.

- The definition of a security verification policy and associated credentialing of the secure communication system capability via the development and testing in accordance with processes that allow guaranteeing the required level of security in a way that is accepted by all service providers and system developers, especially with respect to the notion of trust.

SNS-2022-STREAM-A-01-07: Real-time Zero-touch Service Technologies

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 6 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 3-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

- Availability and characterisation of a service framework and associated technologies, addressing software tools and topology aware processes to deploy functions at the appropriate level of a cloud continuum. The target is to develop effective service deployment and management schemes that will, easily support new vertical services

- Architectures and technologies supporting verifiable actions/decisions without human intervention or without a previous acquired knowledge on the type of response/interaction that is going to happen.

- Availability of service stack enabling reduced energy consumption for service deployment, management and operations.

<u>Scope</u>

The work addresses a flexible and programmable architecture to satisfy the large diversity of use cases and vertical applications. It takes into account maintenance requirements of large IoT deployments, crossing the blurring telecom and IT domains.:

- Enable service providers to act as "platform operators", supporting value creation through a wider community of developers empowered to develop key-in-hand solutions encompassing devices, communications, and computation.

- Hiding the inherent complexities that the management of new generation service lifecycle encompasses, while ensuring the highest level of trustworthiness to the final users/service developers through an appropriate development environment

- Enable improved efficiency in service support, also responding to the ambitions of lower energy systems.

- Include open-source technologies with the aim to develop the most appropriate software development strategies as well as the definition of methods and procedures for guaranteeing that software will a) provide and enable optimal energy performance, b) hide the complexities of the potentially distributed platforms, c) support connected devices requiring lower energy consumption in domains where growth is expected to be massive, (e.g., IoT, consumer electronic, medical devices, etc.)

The above topics listed in the scope represent the core focus of SNS-2022-STREAM-A-01-07, without precluding the potential inclusion of other related technologies still contributing to the listed Expected Outcomes.

SNS- Stream B - Research for Revolutionary 6G Technology and systems.

Specific Challenges and Objectives

This call addresses the industrial and technological long-term challenges that need to be addressed to ensure European leadership for the introduction of 6G mobile Internet systems by 2030 including:

- A reinforced European leadership in connectivity extended to devices, and service infrastructures, with competitive offers to overcome the current challenges of deploying, managing, and exploiting large, distributed sets of consumer- and business-oriented devices, needed to realise the 6G vision of intelligent inter-connectivity between the physical, digital, and human worlds, supporting massive digitisation of our economies and societies.

- The successful digital and green transitions towards low energy and carbon footprint of conventional (vertical) industries, by managing service delivery for an expected massive number of connected devices and objects.

- Solutions to address SDGs and in particular connectivity and service availability (coverage), affordability (cost) and accessibility for a large number of use cases of high public value (e.g., healthcare, agriculture, education, public safety, etc.).

- Efficient support of upcoming innovative applications with performance requirements beyond current technological capabilities, such as the Internet of senses, holographic communications, massive digital twinning, and XR, full autonomous driving, flying networks, digital participation with service infrastructures integrating networking and computational platforms for easy deployment and management.

- Extend the current set of patchy technologies for security and trust towards a comprehensive end-to-end framework, covering virtualized and software based heterogeneous networking environment (e.g., virtualisation of key security functions for protection, detection, and remediation). This pertains to service developers, service providers, and end users, offering the necessary levels of resilience, openness, transparency, and dependability. Such end-to-end security frameworks must be "dynamic", integrating the different ICT involved, establishing monitoring and evaluation provisions, and identifying those responsible for ownership and successful implementation.

The call consequently targets low TRL (2-4) technology advancement as required for future 6G systems. It takes a holistic research approach towards the needed technology, with a value chain perspective covering an integrated ecosystem with IoT, devices and software-based solutions in unified networks. From a comprehensive system perspective, the target is a globally connected continuum platform with the convergence of networks and IT systems to enable new future digital services. This continuum must provide users with improved performance, higher level of control, increased transparency in interactions with digital services, adequate support of ethical values and conformance with societal requirements and readiness (e.g., GPDR, EMF awareness, etc.) whilst contributing to key SDG's.

In that context, the following specific objectives are relevant for this call:

- Significant contributions to the establishment of a globally accepted set of KVI's and KPI's framing future 6G developments

- Dynamic end-to-end distributed security for connectivity, devices and service infrastructures. This security "lifecycle" should be provisioned to account for distributed systems (e.g., asset orchestration and data aggregation), operational security (e.g., a dedicated SOC), security quantification, and a strategy for ongoing security threat assessment.

- A comprehensive zero-touch open end-to-end resource management system with drastic OPEX reduction and innovation support.

- Trustworthy and energy-efficient device, network, and service infrastructures, delivering critical services as well as a dynamic multi-vendor supply market, through new open network and service paradigms.

- Increased spectrum efficiency and dynamic spectrum sharing across multiple (and potentially new) frequency bands (potentially above 100GHz), covering technologies and architectures enabling optimized co-existence with the most difficult spectrum environments, enabling long-term opening of new frequency bands for mobile communication usage with better energy consumption performance, innovative sharing concepts, spectrum re-farming capabilities, and also addressing citizen concerns like low EMF exposure.

- Foster European capabilities in key technologies and notably AI/ML, advanced signal processing and microelectronics, paving the way towards advanced systems realizing visual vanishing (e.g., making the infrastructure imperceptible to the end-users) by fusion with physical environment. Insofar as AI techniques are concerned, the data sets to be used for the training and the evaluation of the mechanisms are expected to be open results from projects. Aspects of provision of such open data sets (e.g., date of release, its scope, and the dimension and diversity of data) will be considered as one of the projects' valuable output for projects with core focus on AI techniques.

- Provide a set of technologies and architectures to reinforce the European industry position during the 6G standardisation phase expected to start around 2025.

6G R&I requires the identification of a 6G performance evaluation framework using a well-defined set of KVI's and KPI's. As 6G is still largely undefined, proposals may consider in the first place KPI's currently contemplated under authoritative industrial/research environments (e.g., NetWorldEurope SRIA, 5G PPP ICT-52-2020 projects, national 6G initiatives or of other regions of the world). To progress towards a European/global consensus on these KPI's, collaborative work across projects of this call is expected towards a European vision and consolidation of the KVI's/KPI's that will frame future 6G developments in Europe.

Considering the specific role of micro-electronic components for future 6G platforms, notably for IoT devices and virtualised "disaggregated" network implementations, proposals addressing such micro-electronic issues are expected to support a collaborative framework enabling to direct specific 6G component requirements towards KDT, in view of maximising the opportunities for the European micro electronic industry to successfully contribute to the mid-term 6G standardisation discussion.

Considering the raising role of IT and cloud technologies for the implementation of IoT and connectivity systems, proposals addressing the cloud and edge cloud technologies and software implementation of network/device control functions are expected to provide a clear strategy in relation to EU supply capabilities and opportunities in the context of a future cloud continuum that may involve interoperation with non-EU systems such as the hyperscalers.

Projects in topics SNS-2022-STREAM-B-01-01, SNS-2022-STREAM-B-01-02, SNS-2022-STREAM-B-01-03 and SNS-2022-STREAM-B-01-04 are expected to actively cooperate with the SNS-2022-STREAM-B-01-05 "6G Holistic System" project (e.g., provide KVIs, KPIs, 6G enablers and solutions, etc.).

SNS-2022-STREAM-B-01-01: System Architecture

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 24 million
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

The expected outcomes support the vision of a massively digitised economy and society calling for intelligent connectivity and service provision across a huge number of heterogeneous domains, resources, and with an unlimited number of application requirements. These cover the availability of:

- An overall system functional architecture to cater for the expected extreme 6G use cases.

- An architecture able to break the boundaries between different infrastructure, service, business, and application environments, capable for a unified service provision across heterogeneous communication and computing environments.

- Solutions for inter-computing beyond the inter-networking capabilities of the Internet, making possible the execution of services across multiple heterogeneous but seamlessly inter-working domains, each possibly applying different policies (e.g., in terms of security, routing, access to resources, etc.), routing mechanisms, access mode to application services, etc.

- An internet-like architecture supporting much higher dynamics and versatility for its topology and service instantiation while significantly lowering energy consumption.

- Architecture and technologies enabling the connectivity and service infrastructure to be programmable with a single, unifying, and open controllability framework, spanning all resources a tenant is authorized to control, including resources from currently separate and heterogeneous domains, such as enterprise and telecom networks, virtual and physical, data centres and routers, satellites, and terrestrial nodes.

Scope

The scope covers the realisation of a unified and open communication and computing architecture beyond the current SBA capabilities. Such architecture will enable seamless operations and service execution across a multiplicity of heterogeneous domains, infrastructures, services, business, and application heterogeneous domains, whilst providing secure and reliable scalability towards an unlimited number of application requirements. Hence paving the way towards massive digitisation. It offers a consistent/reliable programmable environment enabling "tailor made" implementation of various tenants' requirements. Focus is on complementary issues as follows:

- Technologies for scaling Inter-computing systems: The work addresses technologies and system architectures able to efficiently span all resources, regardless of their type (compute, storage, networking), nature (virtual/physical) or location (remote/local/cross domains), dynamically adding and removing resources as they come and go. System control solution aspects effectively handling authentication, naming, addressing, routing and related functions for massive number of elements may also be examined. Resource control takes an end-to-end approach covering the device/IoT domains with service deployment at the deepest possible "edge" in the user vicinity. The work enables a fusion of data communication with distributed computing, transforming the best effort Internet into a sustainable, greener inter-computing system. The needs of service developers and end-users may be considered, such as time-to-market, continuous functional improvements, increasing volumes of data collection for AI, the overall energy cost of providing added intelligence, as well as software foundations and interfaces, with a design-to-cost and design-to-energy efficiency framework.

- Control and controllability separation: Infrastructure programmability is creating a new level of decoupling between the platform delivering the service and the service elements. Network virtualization brings additional degrees of freedom in flow processing and combines edge and network in one logical entity. It addresses optimal system programmability deployment on top of a shared, distributed multi-stakeholder infrastructure (at a horizontal and vertical levels). This is composed of different resources, shared by instantiation from other executed services or slices, while establishing system integrity and self-preservation in runtime for a distributed, dynamic resource environment. The architecture should be able to manage elements of different configurations and implementations, different active modules, deployed on top of more generically

capable resource pool, in a multistakeholder environment. Data quality and trust levels are key parameters to consider as well as potential disruptions in network/service operation and how the overall architecture should respond to these to meet an appropriate resilience level for the service providers and the end users. Concretely, the aspect to be explored here is the separation[15] of service- and tenant-specific control in terms of the generic, autonomic, unified infrastructure and resource controllability featuring high resilience facing resource dynamics, and providing equivalents of so-called "protected modes" known from other execution environments.

- <u>Frictionless inter-domain resource management:</u> The work addresses frictionless and optimised resource management and orchestration across multi-stakeholder cloud, edge, and fog platforms to meet specific application requirements (e.g., latency, performance and other relevant 6G KPI's), with efficient utilisation of resources for both service provider and verticals operating under specific constrains (e.g., resilience, timing, cost, energy, CO2, etc). It includes capability to swap computation loads as a function of efficiency and local energy availability under strict resilience and timing requirements. To address resource control, including resource pooling, service request scheduling and conflict resolution, AI is expected to play a relevant role (e.g., network orchestration).

- <u>Native integration of AI for telecommunications.</u> The massive adoption of AI tools will exacerbate the problem of energy consumption of the ICT infrastructure. Native integration of AI/ML is in scope to implement adaptive decision making at different time scales with expected impact on energy and performance efficiency gains for such distributed multi-stakeholders' systems. The adoption of these tools may trigger changes in the existing architectures. Therefore, it will be crucial to devise energy efficient architectures and computation algorithms to have energetically sustainable communication and computing paradigms for future mobile networks that adequately explore artificial intelligence technologies. Research needs to be done on: i) distributed edge AI solutions, covering consensus convergence, resource limitations, localized data management, transfer learning; ii) adequate development of training data for telecommunications; iii) AI security and comprehensibility of ML for the applications identified above; iv) strongly distributed AI/ML instrumentation integrated at the architecture layer.

- <u>New Data Transfer Paradigms with deep Edge integration:</u> The work considers systems where edge, access and cloud are increasingly undistinguishable (i.e., used homogeneously by the service layer). This work addresses edge-specific requirements originating for example from IoT devices that are service dedicated, intelligent and are yet resource constraint (e.g., micro-electronics for battery driven components). This yields a richness of resources that are challenging when being integrated into a common resource worldview. To support this, novel suitable switching, resource management and scheduling mechanisms that take all constraints into account, whilst relying on edge-specific control agents enabling the enforcement of the policies underlying the switching decisions and scheduling solutions. This further includes new IoT device management techniques that are adapted to the evolving distributed architectures for IoT systems based on an open device management ecosystem. The complexity originating from the diversity of different types of physical devices and communication links is also considered (sensors, user terminals, edge and data centre computers, optical and electrical switches, fibre, and satellite links) together with the diversity of service requirements. Highly scalable resource management techniques with deep compute/communication integration across multiple domain components are needed.

- <u>Improve data plane performance:</u> The work addresses innovative protocols in view of overcoming known Internet limitations as originating from new scenarios and vertical requirements (ultra-low latency, extreme mobility, ultra-high data rates, integration of end-terminals, controlled security, space applications), It addresses functional improvements of the basic transport mechanisms with guaranteed packet delivery, increased dynamics in network topologies as well as compute resources and the resulting required flexibility in routing, while also considering security and precision delivery. These protocols should be able to flexibly operate in local/global architectures and provide primitives to perform the integration of new localized environments in an intelligent ICT

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[15] (meaning: both conceptually and in operations, i.e., with isolation and guaranteed quality levels)

infrastructure (either as overlay or underlay protocols). Brown or green slate approaches may be considered, as well as challenges from hardware architectures, protocol design, semantic approaches, optimized software focused data planes, as well as a clear migration strategy from legacy technologies.

- Deterministic Networking: The work opens an entirely new class of innovative application by enabling deterministic networking, beyond today's best efforts Internet characteristics. It goes well beyond the current work of 3GPP Release 16 targeting industrial applications. It addresses major challenges notably performance requirements: $< 75\,\mu s$ latency (including fibre transmission which adds $5\,\mu s$/km), < 8 ns timing error, and several tens of Gbps throughput for critical signals, values which are outside of the current work. It extends deterministic networking across multiple stakeholders and domains, and the associated strict reliability requirements associated with such networking in dynamic environments should be covered. Key properties of the wireless communication link are considered as an integral component for the overall deterministic network design.

Proposals may address one or more of the topics above.

SNS-2022-STREAM-B-01-02: Wireless Communication Technologies and Signal Processing

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 6 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 30 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

The target outcomes address disruptive research towards wireless communications, reflecting the long-term challenges presented in NetWorld Europe SRIA and covers:

- Wireless technologies and systems capable to meet expected 6G radio capabilities such as Tbps data throughput, sub-ms latency, extremely high reliability, massive mMTC, extreme energy and spectrum efficiency, very high security, and cm-level accuracy localization.

- Technological progress towards exploitation of new spectrum such as the sub-THz or THz spectrum, and the relevant/specific transmit and receive technologies and enabling new range of applications based on a fusion between communication and sensing.

- Innovative RAN (Radio Access Network) facilitating multi-vendor interoperability, and flexible service introduction.

- Technologies and architectures enabling support of new higher efficiency mobile communication approaches, such as cell free networking, with capability to drastically reduce energy consumption and to control EMF exposure levels.

- Applicability and validation of innovative AI/ML based architectures to control L1/L2 functions with optimised feedback control and operations.

- Identification of microelectronics solutions and technologies at RF, Baseband, DSP, processing levels to support future 6G RANs.

Scope

This work addresses the fundamental technologies required for developing the radio components of next generation 6G wireless communications for public or private networks, systems, its coexistence with existing technologies, as well as promoting easier deployment and migration from older RAN technologies. Focus is on:

- Terahertz Communications and Ultra-Massive MIMO: Development of technologies and systems enabling Terabit-per-second (Tbps) wireless communications needed to support long term exponential capacity increase of mobile communication networks. Piggybacking on H2020 results in THz communication, the work further explores technologies above 100GHz with focus on channel measurements, modelling, and sounding strategies, as well physical layer, and signal processing techniques and, notably, waveform design. Due to the shorter wavelength, many antennas can be packed in a small area thus, leading to the concepts of mMIMO and ultra mMIMO which require further investigation. Meta-surfaces to control propagation are in scope as well as work in the computing domain to deal with the massive amount of processing needs of Terahertz communications. Technologies to change propagation characteristics of wireless channels, e.g., through intelligent reflecting surfaces (IRS) or large intelligent surfaces (LIS) are also in scope to enable the replacement of the current cell-/ network-centric approach by a user-centric one where the cluster serving a particular UE can be determined dynamically with realisation of a cell-free mMIMO and uniform services across the network can be offered.

- Joint communication and sensing: Communication work is complemented by work in the field of location and sensing capabilities for devices. It includes joint radar and communications, with signal processing techniques for wideband beamforming, or spatial multiplexing, as well as transceivers for higher spectral efficiencies, better power efficiency, faster data converters, high density digital logic, chip-package-antenna co-design, and combination of silicon technologies with III-V technologies. Waveform design can extend to the radar domain to offer the potential for combined radar and communications capabilities. Experimental prototypes are in scope.

- New Waveforms, Random and Multiple Access: Support scalability of future Machine Type Communication with massive number of connected devices transmitting very sporadic data, with minimum protocol overhead and energy consumption. While strategies relying in the CP-OFDM (cyclic-prefix OFDM) waveforms have been adopted in 4G and 5G, other waveforms (e.g., FBMC, GFDM) allow to relax the strict synchronization and orthogonality conditions of OFDM and, by doing so, increase the spectral containment of 6G systems. Besides other promising multiple-access schemes may also be considered such as Non-Orthogonal Multiple Access (NOMA) or Rate-Splitting Multiple Access (RSMA) to enable grant-free access, or other novel promising directions with potential for adoption at standardisation level (considering not only dense cell but also sparse cell coverage).

- Enhanced Modulation and Coding: Support to innovative channel coding approaches towards "error free" channel transmission. It should solve current bottlenecks in implementation issues such as computational complexity, algorithm parallelisation, chip area, energy efficiency, etc. whilst supporting hundreds of Gigabits per second and low latency. It is compatible with Increasingly massive MIMO-implementations and contribute to the future modulation and coding schemes, possibly mixing data-driven and model-driven approaches, as required for 6G, retaining reliable, energy-efficient characteristics.

- Wireless Edge Caching: Support the capability to deliver Terabytes per month for all in a scalable and cost-effective manner. Focus is on the information theoretic foundations, in the coding and signal processing algorithms, and in the wireless network architecture design, to exploit the potential gain of content-awareness. It covers technologies exploiting edge caching in areas as Coding (e.g., combining edge caching with modern multiuser MIMO physical layer schemes), Protocol architectures (e.g., combining edge caching with video quality adaptation); and AI/ML

based content popularity estimation and prediction, to efficiently update the cached content. Potential vertical-specific developments may be considered as well.

- Human-friendly Radio systems: Support innovative antenna and physical layer technology for higher acceptability of radio infrastructures by citizens. It covers new antennas and new antenna systems, that need to visually blend seamlessly in the urban landscape through use of new designs or new materials, in the context of an increased density of base stations and more complex antennas to support higher frequency ranges. It also covers antenna systems for EMF control and awareness to minimise human exposure. The target antenna work should account for mMIMO and address the limitation of linear increase of the number of antennas to overcome the much higher path loss in THz-band.

- Spectrum Re-farming and Reutilisation: Support future high bandwidth demand and versatile spectrum usage requirements by multiplicity of applications through optimised spectrum management, sharing and dynamic application aware allocation. It covers spectrum reutilisation between RAT's, including NTN access, and addresses new THz spectrum. Novel approaches with use of AI/ML technology for real-time spectrum efficiency is in scope. It also covers specific sharing scenarios for unlicensed spectrum use, and fundamental work on these challenges for new terahertz bands will also be needed.

Proposals may address one or more of the topics above.

SNS-2022-STREAM-B-01-03: Communication Infrastructure Technologies and Devices

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around 5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 25 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

The target outcomes address disruptive research for complementary technologies enabling to support the full potential of future 6G wireless communications and service infrastructure, as presented in the SRIA. It covers:

- The availability of fixed backhaul and longhaul networks with performance levels compatible with 6G KPI's in terms of bandwidth, capacity, latency, and flexibility.

- The availability of viable solutions, both from a technological and cost perspectives, allowing to bring beyond 5G and 6G services to places where terrestrial solutions are not economically viable, hence maximising coverage and access to services.

- The availability of solutions addressing the need to develop 3D scalable networks capable to address flying devices, beyond current network solutions primarily designed for 2D usage.

Scope

The work covers technological progress in optical technologies, NTN technologies, IoT and short-range communication with specific focus on:

- Flexible Capacity Scaling: The work addressed fundamental technologies on backhaul and long-haul networks able to reach rates of 10 Terabit/s optoelectronic Interfaces and multi-Petabit/s for optical fibre systems, operating at symbol rates of more than 100 GBauds, with viable transportation per bit cost especially for high demand multimedia services. It includes the flexible exploitation of new wavelength bands with progress in a wide range of technologies such as optical amplifiers, opto-electronics devices, and sub-systems. Techniques to safeguard optical network infrastructure against data leakage and unexpected service outages, improving system reliability are in scope.

- Ultra-high Energy Efficiency: Develop novel switching optical architectures and new routing protocols, and design new semantic description and information models allowing the control of such optical networks, moving into essentially full-optical transport and control systems, considering new control mechanisms that optimise traffic flows across network layers, particularly if combined with optical space and wavelength switching, and bypass energy-hungry electronic functions.

- Integration of Optical and Wireless Technologies from 2 different perspectives: i) technologies enabling the coexistence of fronthaul and backhaul networks and supporting end-to-end, wireless, and all-optical networks. This covers possible redesign of the backhaul/fronthaul application space such as packet switching with new packet friendly fronthaul interfaces in scenarios where many users generate a low amount of traffic data each, or multi-user mode (MU-MIMO) with an interoperable solution (Layer 2 and 3), reliability, durability, and energy efficiency; ii) in applicability of advanced light related technologies such as LEDs (light-emitting diodes), lasers, outdoor point-to-point devices (FSO — Free Space Optics), point-to-multipoint commercial applications (Li-Fi — Light Fidelity) or between devices (OCC – Optical Camera Communication) and Fiber Wireless Fiber (Fi-Wi), for the design of novel communication schemes, system architectures and protocols, in order to fully integrate these technologies in the communication infrastructure.

- NTN infrastructures: A reference network architecture may be composed of a unified terrestrial and NTN multi-dimensional and multi-layered infrastructure, composed of space-borne and air-borne flying nodes possibly interconnected by means of wireless and optical links, to guarantee seamless and continuous connectivity. More importantly, the envisaged constellation would be structured hierarchically, i.e., flying nodes operating at different altitude and offering user centric coverage. Moreover, the flying nodes may also act as smart edge nodes by implementing storage and computation capabilities to pre-process and store large sets of information, eventually helping to reduce data rate requirements, increase energy efficiency, and guarantee end-to-end network connectivity. Based on the aforementioned network architecture, the focus of the activity will be the design of a novel concept for the seamless integration of NTN and terrestrial networks, with special emphasis on the design of a unified RAN, whose environmental sustainability should be properly addressed in all design implications. In this perspective, the main outcome of the activity will be three-fold. First, the activity should carry out the design of users' antennas for the effective convergence of existing and future wireless networks with NTNs, hence relying also on low-cost flexible beam steering for NGSO satellite constellations and federated beamforming for satellites swarm. Second, a unified waveform will be developed by considering the peculiarities of both terrestrial and non-terrestrial networks (e.g., propagation impairments, doppler effects, delay). Third, horizontal/vertical handover procedures will be developed to allow for the seamless convergence between the envisioned networks, by building on novel cooperation schemes between the terrestrial and the envisioned flying nodes that may implement software defined payload for smarter and more energy-efficient coordination operations in space. The edge capability of flying nodes is also expected to be investigated to find out a trade-off between reduced data rate/increased energy efficiency and operational constraints (limited mass, power, storage) of flying nodes.

- Integrated NTN service provision: Focus is on multi-layered NTN infrastructure service operations supporting service ubiquity, flexibility, scalability, and cost-efficiency, towards realisation of satellite-as-a-service. The work covers software-based non-terrestrial networks allowing full orchestration of the infrastructure resources such as power, bandwidth, time, space dimensions,

node, coverage, and topology for a more flexible and dynamic system with overall better performance, efficiency, and sustainability. A software focus, disaggregation, and virtualization considering the ground and non-terrestrial segment, and their specific constrains are in scope. It should enable edge computing in space with computation and caching. Intelligent and autonomous resource management is sought, towards zero delay infrastructure reconfiguration, optimum orchestration of the infrastructure/service resources, dynamic spectrum management, beamforming and physical layer selection and optimization also by means of AI/ML strategies.

- New IoT components and devices: The work targets the complex task of deployment and management of a large set of distributed devices with constrained capabilities, including components (micro-electronic components) and devices mainly for IoT and vertical sector applications as essential elements of future secure and trusted networks. The focus of the components and devices is on the requirements for the development of ultra-low power IoT (including self-powered and energy harvesting devices), extended to Tactile IoT components and on-IoT device AI techniques and methods. The research may also address IoT device management networking and service techniques that are adapted to the evolving distributed architectures for IoT systems based on an open device management ecosystem.

- Troposphere Networking: The work addresses Tropospheric Networking as the new network serving all the "things" between the ground and ~15 Km altitude and focus on control and communication services for the drone, urban air mobility (future urban transportation systems that move people by air), balloon, aircraft, etc. Application scenarios covering both airplanes and UAVs should be defined and both data and control requirements identified. Solutions that rely on novel device to device (D2D), mesh, and cellular solutions for different types of mobility nodes may be considered, including approaches for unified RAN cellular (or cell free) coverage for both air and ground coverage, including high altitude dynamic beam steering, and efficient network level mobility management. This topic has a transformative potential for the infrastructure strand in general, and is considered particularly challenging if supported only by terrestrial technologies.

- New Physical Layers and associated protocols: 6G networks are expected to operate over all types of communications, in multiple contexts. Research is sought on promising strategies to revolutionary new mechanisms for short range networks, technologies that expand the current limitations of cabled media, and technologies that provide low-power answers to interconnection of multiparty IoT resources.

- Nano-Things Networking: The work addresses technologies to extend connectivity towards micro things, towards the realisation of nano-communications extending the reach of smart control to the level of small/tiny things, including molecules and cells. Materials with software-defined electromagnetic behaviour constitute applications t, paving the way for programmable wireless environments. The focus is on nanomaterials and nano-network architecture components (nodes, controllers, gateways) opening new prospects of usage of nano-scale things. At the PHY Layer, graphene antennas enable nano-communication within the 0.1 - 10 THz spectral window, which promises unprecedented communication data rates despite the nano-scale. At the MAC Layer, pivotal protocols could target Body Area Network (BAN) applications notably for health and self-monitoring and adapting industrial materials. This topic is considered of potential transformative impact across the communication ecosystem.

Projects may address one or more of the above topics.

SNS-2022-STREAM-B-01-04: Secure Service development and Smart Security

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 5 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 20 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 2-4 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

The target outcomes qualify the needed level of reliability, trust and resilience that applies to a critical infrastructure like 6G based on a globally connected continuum of heterogeneous environments supported by the convergence of networks and IT systems to enable new future digital services as follows:

- Identification/characterisation of the threat landscape applying to future end-to-end 6G connectivity and service systems and of the technologies and architecture to mitigate them.

- Availability of technologies supporting the necessary levels of trustworthiness, resilience, openness, transparency, and dependability expected under the EU regulations (such as GDPR and Cyber Security Act, including associated provisions including new certification processes etc) across a complete continuum incorporating the human-cyber-physical system including connectivity-service provision.

- Availability of technologies ensuring secure, privacy preserving and trustworthy services in the context of a programmable platform accessed by multi-stakeholders and tenants including vertical industries as users.

- Availability of security technologies and processes addressing the challenge of open-source solutions developed in the context of multi-vendor interoperability.

- Secure host-neutral infrastructure where multiple infrastructure providers are involved in the deployment, hosting and orchestration of the network service.

- Identification of the life cycle of smart services security and trust requirements including development, provision, operation, maintenance and of their business impact on the stakeholders' ecosystem.

- AI technology applied to security in two ways: i) correct application of AI to enhance security in 6G; ii) consideration of potential security threats using AI.

Scope

The scope includes a set of complementary topics which will handle the securing of 6G technologies. Topics included are:

- Human Centric methods that give the control to the user to guarantee privacy and confidentiality, for both service development and service execution. It addresses potential biased usage of AI and includes both the threats directly applicable to user data traffic, and their control and management. Methods for quantification of security to make the users aware of the systems and services used and associated risks is in scope as well as technologies for enhanced policy management (including huge data analytics, AI and cloud-native management and serverless approach) and facilitating human-understandable policies on trust and security of automated systems, to raise user awareness.

- Holistic Smart Service frameworks which with secure lifecycle management and operation cover the development, provision, deployment, orchestration, and consumption of services for a new computing continuum that spans across multiple heterogeneous domains. Holistic Smart Service Frameworks include: a) IoT Device-Edge-Cloud continuum management and orchestration on virtualized and software-based elements, hardware accelerators, well as serverless frameworks, enabling zero-touch service automation; b) abstraction methods to support the network elements

and providing flexible APIs, facilitating their combination addressing different orchestration styles at blurring RAN, MEC, Core and Cloud segments; c) new service developments to exploit of infrastructure slicing and sharing, capability exposure, discovery, and composition, for end-to-end management in the ICT continuum; d) end-to-end resource self-configuration and management based on key parameters such as service type, network traffic, channel conditions or mobility scenarios; e) composition methods able to handle situations where interconnected services are not known in advance, and able to model consequences (e.g., "digital twins") with legal or ethical dimension, including new service-models that enhance human-centricity and interaction capabilities.

- Secure Lifecycle management targets the provision of a smart, secure, adaptive, and efficient service management, spanning the lifecycle of smart networks and services (including vertical support), to manage risks and costs. It covers improved predictive orchestration algorithms for optimal usage of resources (processing, storage, networking) in terms of trust and risk level whilst bringing down OPEX and energy consumption for flexible provisioning of service instances and supports recursive deployments of functional components for secure multi-tenancy. It addresses AI-based service co-design to evolve DevSecOps methods that meet ethical, legal, social, economic, and energy-efficiency requirements together with tools for 'security by design' and for creation of "safer" services, to manage risks from dynamically evolving requirements and threats. Drastic incident reduction and response time for massive supervision of infrastructure elements is in scope as well as mechanisms for infrastructure and service certification for security and performance. The work also covers secured programmability with mechanisms to verify data authenticity and truthfulness (e.g., smart contracts, fact checking services), along with trusted digital interactions, especially in dynamically- composed service environments, including software engineering methodologies and tools and cost-effective certification in dynamically changing systems

- Efficient security enablers build capability for untrusted environments. Security techniques using Artificial Intelligence, rule-based, statistical, contextual analysis and potentially relying in Distributed Ledger Technologies to improve trust in networking elements and service functions are in scope, as well as techniques to guarantee the trustworthiness and security of systems based on disaggregated cloud environments and able to reliably handle seamlessly any hardware of software element from different suppliers. Enablers can build upon developing technologies such as Full Homomorphic Encryption (FHE), Multi Party Computation (MPC), Zero Knowledge Proof (ZKP), Anonymisation/pseudonymization, data integrity of AI-based process constitute a set of relevant topics. Enablers should help to anticipate known potential threats which will mature based on other technological advances within the timeframe of the development and potential first deployments of 6G. Such threats though not yet active, are well known and are anticipated by the ICT community (e.g. Shor's algorithm). New cryptographic techniques, and techniques to manage and distribute keys, are in development and maturing. Such techniques may be applied to end-to-end smart network security, reaching beyond performance and protection capabilities of traditional symmetric and asymmetric cryptographic and associated key exchange techniques.

Projects may address one or more of these topics.

SNS-2022-STREAM-B-01-05: 6G Holistic System -

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 23 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 23 million.
Type of Action	Research and Innovation Actions

Technology Readiness Level	Activities are expected to achieve TRL 2-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

This project should provide a global end-to-end system framework building up on the 5G PPP results that are targeting 6G networks, provide new solutions for well selected topics and identify the place and role of each topic from the above-mentioned 4 strands. Results generated in other frameworks (e.g., national or international 6G initiatives) may also be considered as appropriate. The project should equally investigate both societal and technical aspects to cover citizen needs in 2030 and beyond.

It shall provide at least the following results:

- A complete system perspective of future 6G SNS platform, from an architectural and functional perspective and from an end-to-end, user-to-user (human and automated) perspective, integrating key results of other strands of Stream B as they become available.

- The consolidation of 6G KPI's and KVI's as federating SNS targets for European R&I in the field.

- The identification of key 6G use cases, their requirements, and how they can be supported by the 6G retained architecture/technologies.

- The identification of the most promising technologies, being evaluated under a complete system design approach, towards the realisation of the 6G vision.

- The translation of societal/ethical use case needs, targets and objectives into technological requirements and the identification of the technologies that can match these requirements.

- The identification of critical technologies for future standardisation work.

The project should, with equal importance and prominence, investigate societal needs, including KVIs and their related KPIs, as well as technologies in areas indicated in the above Stream B strands, that are promising to fulfil these requirements and needs. It is expected that the societal KVI outputs of the project can be used as a prominent platform to establish a dialogue with the civil society whilst the outputs on technologies and architectures support European voice in global technological fora.

Also, this project should provide well-defined means of communication with the 6G-IA[16] (i.e., 6G-IA Working Groups) for ensuring that the vision and directions of the European ICT community are appropriately captured. An advisory board of experts and representatives from key public and private stakeholders and organizations may be considered. In that context, the project should be open to incorporate, where relevant, results and approaches originating from key stakeholders beyond the project partners.

Scope

6G networks should take into consideration societal requirements as well as technological improvements. For that purpose, the project should equally address both aspects with the ambition to cover the duality of the European approach: "Sustainable 6G" and "6G for sustainability". The overall goal is to Identify the technology needed to provide value to the society, being environmentally and economically sustainable.

The project should equally address both of the following aspects:
- The consolidation of 6G societal and technical requirements, KVI's and KPI's, to serve 6G use cases and the associated architectural and technological avenues to realise them. It consolidates results of other technological strands and provides comparative assessments of the various

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16 Previous name of the Association: The 5G Infrastructure Association (5G IA)

solutions, pushing the limits if technology and building a generic 6G toolbox with trade-offs across topics that will be investigated by more than one project (e.g., minimization of the energy consumption, coordination of AI/ML solutions in deployed in different network domains).

- The Societal focus and technologies to address societal goals is an important aspect. A widely validated approach should be developed to transform key SDG requirements into technological solutions and performance objectives.

The work also identifies key technologies to convey towards standardization with common approaches with users, towards the realization of a consensus framework including verticals from the onset. It is expected to be supported by the key 6G players of Europe across the value chain, including development of components and the needs of vertical industries, spanning industry to academia. This provides the view of a European technological solution for the consolidation of a 6G vision, objectives and technological developments leading to strong European position at standardization level, and paving the way towards future deployment.

The project is planned to start concurrently with other Stream B RIAs as several activities are needed before integrating the results and key findings of SNS Phase 1 Stream B projects. These activities indicatively include the definition of an appropriate set of 6G use cases, KVIs and KPIs incorporating the analysis of key findings from pre-6G technologies (5G PPP and other topic related initiatives). This should include the setup and work on key topics that the stakeholders of the project will identify as important for 6G networks and that may not even be included in other Stream B Strands, etc.

SNS - Stream C – Smart Network & Services experimental infrastructure

Specific Challenges and Objectives

The challenge is twofold:

- To validate and reduce the introduction risk of candidate 6G technologies, components and architectures at system or sub-system level, in view of their downstream adoption at standardisation and at market level

- To show the applicability of such technologies to efficiently support advanced application and use cases not supported by current 5G systems.

The main objectives of this call are hence twofold:

- To develop EU wide experimentation platforms that can incorporate candidate 6G technologies for their further validation.

- To make such an experimentation platform capable of hosting advanced pilot "6G" use cases as targeted under Stream D during the subsequent SNS implementation phase.

Related objectives include:

a) Reusability and evolvability of the experimental platforms over the lifetime of the SNS programme: The target is to follow a spiral development where platforms or specific components can be further extended to ensure a continuous integration of the most promising 6G technologies using agile methodologies. The developed platforms should be available for use from future Stream D projects.

b) Accessibility and openness: use of the platform in further phases of the SNS by any consortium, requires using modular implementation methodology, potentially open-source solutions with well-defined technological and business interfaces clearly documented.

c) Directionality and optimisation of previous and related investments in Europe: Early 6G PoCs may be supported by existing facilities, e.g., evolved 5G Infrastructure Platforms integrating new components or facilities developed in software engineering/cloud projects or IoT Large Scale Pilots or other technology-oriented projects that allow the investigation of open ecosystems (e.g., Open RAN). Leveraging 6G investments by Member States is also relevant in this context.

d) Disruption friendly: experimental facilities, even if originating from earlier experimental initiatives, should be capable of hosting possible upcoming 6G disruption and hence guarantee their future-proofness.

e) End-to-end: the target experimental facility should be capable of demonstrating E2E service capabilities and include a full value chain including IoT devices, connectivity, and service provision.

A well-designed integration of existing components (i.e. PoCs) to create an experimental platform will allow a constant improvement on services and technologies to be tested in the SNS Partnership. This integration will allow the test of complete systems that will become the basis of 6G networks and thus, create new knowledge and ideas.

SNS-2022-STREAM-C-01-01: SNS experimental Infrastructure

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 5-10 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Indicative budget	The total indicative budget for the topic is EUR 25 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 4-5 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 90% for profit organizations

Expected Outcome

The main outcome will be the availability of an evolvable experimental infrastructure for the duration of the SNS programme that covers as many capabilities as possible to:

- demonstrate the performance of key 6G candidate technologies, components, and architectures. To that extent, technologies as identified notably under Stream B Strands may be considered as a baseline

- demonstrate technological feasibility of "better than 5G" KPIs, related indicatively to capacity, ubiquity, speed, latency, reliability, density of users, location accuracy, energy efficiency, service creation time, network management CAPEX/OPEX. It will include capability to incorporate emerging 6G specific KPI's and the capability to address key KVI's as developed by ICT52 projects. KPI's from this project may also be taken as reference objectives in that respect.

- demonstrate innovative radio spectrum technologies and the use and sharing applicable to beyond 5G and 6G spectrum. This should include, if appropriate, licensed, unlicensed, or licensed-shared access. It also includes novel spectrum at THz bands.

- validate a representative end-to-end beyond 5G architecture (and later 6G) including end-to-end service provisioning with slicing capabilities and ability to accommodate technological and architectural disruptions of 6G

- demonstrate performance of disaggregated architectures, both at interface level (interoperability) and at cloud implementation level (Open RAN).

- validate landscape aware and end-to-end security architectures and technologies.

- validate multi access edge computing scenarios and their integration into a complete cloud continuum with representative opportunity from the EU supply side.

- integrate full value chain experiments covering IoT/devices, connectivity, and service delivery.

- support innovative use cases with vertical actors, beyond 5G capabilities, and to support showcasing events

- demonstrate and validate performance of innovative 6G applications with a focus on the Internet of Sense (integration of communication and sensing capabilities) and on demanding immersive applications such as holographics, digital twins and/or XR/VR.

- support to impactful contribution to standards.

- demonstrate the technological feasibility of key societal requirements and objectives such as energy reduction at both platform and use case levels, EMF impact and acceptability, sustainability, and resilience. Other key societal indicators include coverage, accessibility and affordability of the technology.

- validate management functions such as zero-touch and fully automated operation with a high level of trust with security measures and processes including and covering the full technological chain, from device to service provision and execution of trustworthy and exchange of actionable information.

Scope

The target beyond 5G/6G experimental infrastructures provides the capability to demonstrate and validate the most ambitious use case scenarios as deriving from the European 6G vision. This includes the capability to interconnect the physical world, the digital world and the human world based on a connectivity and service platform with performance capabilities beyond current 5G platforms and IoT application scenarios. The target experimental platform hence includes validation capabilities at every relevant layer of the IoT-connectivity-service provision value chain, covering at least innovative components and microelectronic capabilities, fixed/multi radio access (including NTN), backhaul, core network, and service technologies and architectures, covering disaggregated scenarios like Open RAN, Core, or blurred RAN/core scenarios. It includes end-to-end virtualisation and network slicing as key components to support multi-tenant environments, integration of private/non-public and public networks and multiple vertical use cases. It also includes the device and IoT integration and the cloud edge capabilities with scale up capabilities for demanding services-based on a clear EU strategy for an edge integration into a complete cloud continuum. The experimental platforms will offer the capability to support disaggregated architectures enabling software and hardware implementations that goes beyond the 5G architecture and that will eventually be able to support 6G services. It is also futureproof by enabling to incorporate novel or disruptive technological approaches, and notably new spectrum and associated technologies, "AI-based service architectures", communication and computing integration, AI-based zero-touch management and intelligence connectivity, integration of communication and sensing capabilities as typical, though not limitative capabilities. The experimental platform is also capable for supporting and demonstrating key non-functional properties and in particular end-to-end security, security provision in the context of further integration into a larger environment (hyperscalers), energy efficiency at both platform and use case levels, and EMF-awareness.

The demonstration capabilities of the target platform are to be assessed against a set of well-defined KVI's and KPI's. As 6G is still largely undefined, proposals may target in the first place KPI's currently contemplated under authoritative industrial/research environments (e.g., 5G PPP ICT-52-2020 projects, and national 6G initiatives or of other regions of the world). However, the proposals should be flexible enough to accommodate new relevant KPI's as they become available from the wider 6G community and from potential use cases.

Beyond technological validation of critical components, technologies and architectures, the experimental platform provides the required openness to host vertical use cases pilots. It is desirable that the platforms support open framework principles (e.g., both legal and technical like open APIs) enabling future vertical projects to access and use them. It is also strongly desirable that these facilities are built in a way that allows the evaluation of competing technologies where appropriate.

Such experimental infrastructure may be based on the integration of components in several solutions developed in the context of previous initiatives like the 5G PPP, IoT or cloud computing projects or in the context of ongoing European 6G initiatives, also at the national level, but this is not a pre-requisite.

Each Project may include multiple components in different locations/countries, targeting interconnections between them to create a pan-European experimentation Platform. It is important to note that the stakeholders will facilitate easy replication of results in the same or additional locations/countries if this platform will be selected for large scale trials as part of subsequent phase of Stream D.

The target experimental facilities and their modules should be open and accessible for a long enough period to allow for an easy handover from one phase to the other. Conditions should allow experimental facilities to be easily reused under fair and reasonable conditions for subsequent phases of the SNS programme implementation.

In view of ensuring maximum take up of the validated technologies, proposals should include a significant representation of European industrial players with strong demonstrated impact at standardisation level.

SNS - Stream D – SNS Large Scale Trials and Pilots (LST&Ps) with Verticals,

Specific Challenges and Objectives

The challenge is to prepare very early in the SNS programme future adoption and market take-up of European SNS technologies and systems. The 5G experience has shown that it takes several years to prepare adoption of 5G systems by key vertical players. The challenge is thus to validate beyond 5G and 6G technologies in a user context to maximise downstream take up. Beyond the technological validations of Stream C, this Stream targets:

- The validation of SNS KVI and KPI's and in the context of very advanced digital use cases implemented through Large-Scale Trials and Pilots (LST&P)

- The identification of use case specific KVI and KPI's and how they may be matched by SNS platform KVI and KPI's

- A structured feedback loop from vertical users towards SNS stakeholders, in view of ensuring the best match between beyond 5G/ 6G systems capabilities and users.

- Accessibility and openness: use of the infrastructures/platforms in further phases of the SNS by any consortium, requires using modular implementation methodology, potentially open-source solutions with well-defined technological and business interfaces clearly documented.

One of the most important factors for the success of 6G networks is the creation of ecosystems with verticals identifying real business pain points and how these can be addressed by advanced technological solutions. As this is a lengthy and difficult multidisciplinary process, Stream D is planned to start from the beginning of the SNS Programme.

A related target is to reuse as much as possible, during the lifetime of the SNS programme, available experimental facility capabilities, in line with the spiral approach proposed under activities related to experimental validation. Therefore, this work-programme intends to leverage relevant beyond 5G/6G solutions available from the 5G Infrastructure PPP Phase 3 or from other European initiatives, also at the national level, in this field. These solutions should be linked to the already identified 6G enablers (i.e., AI/ML, cybersecurity, HPC, advance IoT solutions) to ensure a high probability of reusability during the next phases of the SNS Programme. Also, they should take advantage of the 5G flexibility on the design and deployment of new network functions. It is expected that over subsequent phases, validations will address ever more complex use cases eventually realising the 6G vision targeting intelligent connectivity and interactions between the physical, the digital and the human world, and based on advanced features such as a fusion between the communication and sensing environment, Immersive experience including XR/VR, Digital Twins, and Holographic communication. Therefore, the proposed infrastructures/platforms should follow a modular approach addressing that the developed solutions will be future-proof.

To be easily reused during subsequent phases of the SNS programme implementation, the target infrastructures/platforms and their modules should be open and accessible during a large enough period allowing for easy handover from one phase to the other.

The activity should also target visible and high-level exposure of European capabilities and leadership in beyond 5G/6G technologies through support of large showcasing events.

Concerning security, due to the potential use of 5G and 6G infrastructures for safety-related services and their relevance to public security and public order, it is essential to ensure the highest level of cybersecurity in this sector. According to Article 170 of the Council Regulation establishing the Smart Networks and Services Joint Undertaking, actions involving network elements deployed for large-scale experimentation or piloting may have to follow security scrutiny assessments.

Proposals are expected to demonstrate EU added value, with particular attention to the role of suppliers in the cyber-security of the network elements deployed for large-scale experimentation or piloting, as well as in the development of a sustainable supply chain from an EU perspective.

In addition to such an assessment in the context of the potential impact of the proposed project, any remaining security concerns in proposals need to be addressed. In the context of 5G networks, the role of suppliers has been identified in the EU coordinated risk assessment and the EU Toolbox on 5G cybersecurity as of particular relevance for cyber-security.

Cyber-security risks identified in the Toolbox are less likely if the active components and related services are provided by entities established in Member States and not controlled from third countries[17]. Moreover, the toolbox foresees strategic measures to foster a sustainable 5G supply and value chain in order to avoid long-term dependency. In this context it identifies the specific strategic measures necessary for the Commission to ensure that participation in Union funding programmes in relevant technology domains will be conditional on compliance with security requirements, by making full use of - and further implementing - security conditions.

In the context of stream D, the following security issues are particularly relevant among others:

1) A test infrastructure is connected to an operational network, or is using resources from an operational network. This could lead to a cyber-security risk in scope of the 5G cyber-security toolbox.

2) Large scale test infrastructure is standalone, i.e. not connected to an operational network, but utilises close-to-commercial equipment. In this case, connectivity of this operational equipment (or of equipment from vertical companies trialling specific use cases) to equipment from entities established in or controlled from third countries may lead to exchange of project results potentially causing a security risks or undermining a sustainable supply chain from an EU perspective.

Therefore, to ensure the highest level of cybersecurity, as well as a sustainable supply and value chain in the area of 5G, beyond 5G and 6G, it is of utmost importance to ensure that sensitive cybersecurity related information and project results are protected and not, other than in exceptional circumstances, exposed, either for cooperation purposes during the project or after the project, to entities not established in Member States or controlled from third countries. This should in particular apply to suppliers of equipment as well as suppliers of relevant services.

Such security considerations are relevant for the assessment of the potential impact and, if necessary, to be considered in a security scrutiny assessment, where project results considered as security-sensitive information need to be exchanged among project partners.

Implementation modalities are specified in the call conditions under Appendix 1.

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[17] According to the EU coordinated risk assessment of 5G networks, the risk profiles of individual suppliers can be assessed based on several factors. These factors include the likelihood of interference from a third country. This is one of the key factors specified in paragraph 2.37 of the EU coordinated assessment.

SNS-2022-STREAM-D-01-01: SNS Large Scale Trials and Pilots (LST&Ps) with Verticals

Specific conditions. For all other call conditions, see Appendix 1 **Note that Stream D will be subject of a security scrutiny procedure, see Appendix 1.**	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 10-15 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 46 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to achieve TRL 5-7 by the end of the project – see General Annex B.
Funding rate	100% non-for-profit organizations, 70% for profit organizations

Expected Outcome

- Contribution to the long-term availability of sustainable seamless E2E evolved 5G and 6G test infrastructures including capability to integrate vertical use cases specific performance/KPI requirements, as applicable also across public and non-public networks and services.

- Validated core technologies and architectures (also developed in 5G Infrastructure PPP Phase 3 projects and in IoT and Cloud/Edge projects) in the context of specific vertical large-scale pilot use-case implementations and relevant deployment scenarios.

- Validated core technologies and architectures across the value chain (IoT, connectivity, services) for differentiated performance requirements originating from concurrent implementation of use-cases and specialized services for verticals.

- Viable business models for innovative digital use cases tested and validated across a multiplicity of industrial sectors, including demonstration of required device/network/service resource control from the vertical industry business model perspective.

- Support to Impactful contributions towards standardisation bodies notably for 6G use cases and technologies.

- Europe 5G Evolution and 6G know-how showcasing.

- Stimulate large industrial stakeholders, SMEs and the European Academic and Research community to timely engage in experimental activities aimed to validate technological trends for 6G networks.

- Repository of requirements from verticals and of "lessons learned" to prepare for subsequent phases of the SNS programme. It should include records and evaluation of 6G KPIs considering 5G Evolution and the aforementioned requirements and validating them with services linked to specific vertical sectors and related KVIs.

- Contribution to a repository of open-source tools and modules that may be openly accessed and used by SNS projects over the programme lifetime.

- Collection of new requirements that will be used by SNS Phase II Streams A and B projects. Requirements on the network infrastructure will be collected and driven notably by:
  - the emergence of new application domains like (1) the "Internet of Sense", realizing a fusion between the communication and sensing environment, (2) immersive environments like XR/VR, (3) digital twins and (4) holographic type communication.

- A wider application of edge computing and the need to support new classes of requirements related to compute/capacity intensive applications.

- The long-term integration of different cloud/computing environments towards a distributed network environment with landscape unified management

- The blurring boundaries between networks, computing and devices, leading to a need to redesign applications and functions that operate on a dynamically adapting environment, enabled across public and non-public networks.

- The need to reassess an optimized computing/connectivity continuum from an energy consumption perspective.

- The native support of AI and ML by future networks to optimize their operation and allow automated solutions that will be trustable.

- The introduction of zero-touch solutions targeting at OPEX reduction.

- The possibility to provide AI as a service to vertical services and applications.

- The need to offer the highest end-to-end trustworthiness and supporting security measures in public and/or private networks and in the applications running on end devices that transfer actionable information.

- The need to consider open architectures for innovation and vertical use cases integration, enabled by APIs facilitating advanced application and network interaction and mutual awareness.

- The need to address SDGs such as, but not limited to, affordability and ubiquitous accessibility of infrastructures.

- The need to guarantee a high resilience to provide high service availability to end-users.

Scope

The target beyond 5G / 6G validation work through large scale trials is expected to cover at least the following domains:

- Application level: two cases may be considered: i) applications already possible with 5G like AR/VR. Validation should demonstrate clear benefits of the considered technologies and architectures in terms of scalability, security, and performance improvements in line with medium to long-term socio-economic scenarios. ii) applications that are not considered within the 5G current developments, such as applications to eventually create a 6G network with a sixth sense that intuitively understands human intentions, making human interactions with the physical world more intelligent, effective, and anticipating our needs (towards Internet of Sense). In that case, the validation should primarily address technological feasibility and affordable deployment.

- Management level: the validation should demonstrate the efficiency of the end-to-end resource management technologies and architectures, through two aspects: i) significant improvement of (new) resource usage efficiency, towards zero-touch management and effective OPEX; ii) additional capabilities offered to vertical users through open interfaces enabling more efficient implementation of use cases (e.g., AI for networks vs. network for AI at the application level).

- Societal level: the validation should demonstrate significant improvement of key parameters like energy consumption (both for the SNS platform and the vertical use case), safety (inc. EMF exposure), coverage and access, cost and affordability, trustworthiness, security and privacy being part of the priority SDGs to demonstrate in "user context".

The Large-Scale Pilots should be carried out from an end-to-end perspective, with representative technologies covering the full value chain, including devices, connectivity, and service delivery. They should demonstrate the integration of different IoT/cloud/edge/computing environments (public and/or

private) towards a distributed environment with a landscape unified management able to support the emergence of a European offer and capability in that domain.

It is expected that beyond the vertical sectors already quite advanced on 5G and structured around 5G Associations (e.g., automotive with 5G-AA and industry 4.0 with 5G-ACIA), other less advanced sectors will join the initiative. This applies notably to sectors highly related to public policies like healthcare, energy, and public safety, also more relevant in a post covid-Green Deal context.

Projects will involve and call for SMEs, scaleups and startups. SMEs, scaleups and startups are expected to play a key role in this process with new market-driven applications that can build value on the 5G infrastructure. This support will be a critical enabler of European-led innovation, fast track adoption, and stimulate private sector investment, across verticals.

The performance capabilities are to be assessed against a set of well-defined KVI's and KPI's. As 6G is still largely undefined, proposals may target in the first place KPI's currently contemplated under authoritative industrial/research environments (e.g., 5G PPP ICT-52-2020 projects, national 6G initiatives or of other regions of the world). However, the proposals should be flexible enough to accommodate the view of KVI's and new relevant KPI's as they become available from the wider 6G community and from potential use cases. Also, performance improvement in all domains requires definition of a benchmark against which improvements may be evaluated. Cross project collaboration is needed to define such a benchmark that will be part of the target outcome KPI repository of the SNS Partnerhsip. Also, it is expected that software entities implement the target services in Open-Source Code and with open interfaces for further reutilisation in subsequent phases.

SNS LST&Ps are expected to attract the participation of vertical industries in view of stimulating a strong European participation in future downstream standardisation phases. Therefore, participation of industrial actors with demonstrated strong standardisation impact is desired.

In this early phase, the projects may leverage the existing platforms, or components from them, from 5G Infrastructure PPP Phase 3 End-to-End Facility projects or/and Vertical Pilots projects and/or relevant national or international (ESA) initiatives). The projects may also leverage as relevant/appropriate existing IoT/Cloud/Edge platforms or components that may be integrated together. A smooth transition is envisioned from 5G Infrastructure PPP activities to capitalize on existing results.

SNS Initiative Coordination and Support Actions (CSAs)

The SNS projects under streams A to D are to be implemented as a programme using complementary grants. The respective options of the Model Grant Agreement will be applied to facilitate this. This requires cooperation of the implemented SNS Research and Innovation Actions (RIA) and Innovation Actions (IA) towards joint leveraging of results.

Within the 6G SNS initiative it is foreseen to have two key streams of CSA activities across the life of the programme the operational CSA stream will perform the core activities of organisation and operation of the working infrastructure of the initiative and all of the working structures within it, while the liaison stream will act as the Global ambassador for the SNS initiative.

It is envisaged that two focussed CSA actions, with a total budget of 5 million Euros, will address the scope of the activities necessary: The first CSA will focus on the internal operational aspects of the SNS Partnership, and the second CSA will focus on the external liaison relationships and communications of the SNS community as a whole.

Both CSAs will cooperate with the SNS Office to:

- Monitor the openness, fairness, and transparency of the JU process, including sector commitments and leveraging factor.
- Ensure an effective "inclusiveness" policy to involve diverse sector players

Considering the strategic support nature of the CSA's, they should demonstrate a strong capability to tightly liaise with the JU Public and Private Members and to tightly integrate their work plan with the operational plans of the Public and Private Members of the JU with the private Member and stakeholders at large.

In this topic the integration of the gender dimension (sex and gender analysis) in research and innovation content is not a mandatory requirement.

SNS-2022-STREAM-CSA-01: SNS operational CSA

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 3 million would allow this topic to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 3 million.
Type of Action	CSA
Funding rate	100% non-for-profit organizations, 90% for profit organizations

The prime objective of the coordination and support work is to facilitate the activities of the European SNS Initiative, as outlined in the SNS contractual partnership, expanding first phase activities, and preparing for subsequent phases.

In addition to this, the CSA project has a second prime objective to capture and promote the European view on 6G, the achievements of the 6G SNS and monitor the development and impact of these results on the evolution of 6G in Europe over the period of life of the 6G SNS initiative. This work will also look to the future and consider what additional actions are necessary to maintain the European momentum and leadership in 6G and facilitate the uptake of 6G by the European vertical sectors.

During the planned 6G SNS initiative period a lot of the 6G developments, global 6G regulations and integration of 6G into sectorial business models and processes, need to be studied and stimulated to enable the full potential of 6G networks, services, and devices in Europe. A key activity will be to support international collaboration SNS CSA in promoting the 6G SNS initiative views across the wider community of 6G SNS stakeholders, from national authorities, European member states initiatives, peer initiatives (ESA, Eureka, etc.), European standards communities and the Global 6G discussion to ensure European leadership in the area. *A very tight cooperation with the JU public and private members is expected*

Expected Outcome

The following expected outcomes should be addressed:

- Development of the Europe wide platform addressing the Communication Network Technologies and systems in the context of 6G global developments.
- Support for the identification of strategic R&I orientations including at global level, the coordination of R&I results/initiatives at EU scale including Member State level initiatives, the dissemination and web presence, the organisation of Europe's contribution to standards, and the identification of international cooperation priorities across key regions.
- Support for the Smart Networks Services (SNS) institutionalised European partnership and the related programmatic organisation through cross SNS projects coordination.
- Organisation of the SNS as a coherent programme with clear links to the 6G Infrastructure Association and the EC via the partnership board and the JU Office and their strategic policies.
- Generation, publication, and promotion of common technical papers showing the work and consensus of the SNS projects.

- Maximised output and exploitation of SNS project results in key domains (e.g., standardisation, spectrum) through managed cooperation between projects on horizontal issues.
- Constituency building, stakeholder support, support to key international cooperation events; dissemination, support core inter-project cooperation activities, relevant stakeholder events; definition of future R&I actions.
- Inter JU coordination and joint actions
- Periodic update of the SNS SRIA
- Production of a yearly achievements report
- Continual improvement process based on regular assessments of SNS KPIs and strategic actions via future workplans to improve the achievement of the SNS goals
- A close working relationship with the SNS External Cooperation and Global 6G Events CSA
- *A strong cooperation with the operational process of the private Member of the JU, notably in support of R&I, events and stakeholder management at large.*

Scope

The proposed CSA shall liaise with the SNS RIA and IA actions under Streams A to D and the JU Office to exploit synergies for:

- Stakeholder management towards R&I orientation and SNS cross-project coordination and cooperation (implementation of the cross-project cooperation contractual clause);
- Europe wide cartography of relevant Smart Network initiatives and identification of strategic cooperation opportunities, in particular with initiatives at Member State level
- Design upgrades and perform maintenance on the European SNS web site and program infrastructure (web sites, mail systems, repositories, etc.).
- Working group management and organisation for issues of common interest, supporting a common EU 6G vision and its technological realisation.
- Monitor and communicate with related European member state initiatives.
- Monitor and communicate with peer JU Partnerships (e.g., HPC, KDT, AI, Data and Robotics, Photonics Europe, CCAM).
- Organization, management and support of Impact Assessment and Facilitation Actions (IAFA) as described in the SNS Partnership Proposal.

SNS-2022-STREAM-CSA-02: SNS External Cooperation and Global 6G Events (G6GE)

Specific conditions. For all other call conditions, see Appendix 1	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 2 million would allow this topic to be addressed appropriately.
Indicative budget	The total indicative budget for the topic is EUR 2 million.
Type of Action	CSA
Funding rate	100% non-for-profit organizations, 90% for profit organizations

The International Cooperation and Global Events CSA has the prime objective to present leverage and position the activities and achievements of the European SNS Initiative, as outlined in the SNS contractual partnership, in the major European forums and in the global context.

This work will also maintain dialogues on key strategic issues with the peer communities globally to facilitate consensus building on issues such as spectrum allocation, global 6G regulations, etc., with a view to ensuring recognition of the value and quality of the European 6G solutions.

A strategic aspect of the external relationships is to cooperate with projects outside of the 6G SNS Initiative, on the use and uptake of the 6G SNS network architecture(s) and interfaces. This involves supporting many relationships to national programmes, EUREKA Clusters (in particular the Celtic-Plus Cluster), Peer Partnerships (e.g., HPC, KDT, AI, Data and Robotics, Photonics Europe, CCAM, etc.) and Associations (e.g., 5GAA, 5GACIA, etc.) and other objectives in the HEU as possible.

International liaison and discussions are a critical part of positioning the European 6G SNS initiative on the global stage. It is essential that the 6G SNS JU results are available, and the achievements can be peer reviewed by other regions and initiatives to ensure that they are respected and used for consensus building as a precursor to international standardisation.

A further dimension of the 6G SNS liaison work will be the promotion and representation of the 6G SNS work in global fora. This will involve seeding project presentations at international fora and, in selected cases, orchestrating demonstrations at intercontinental meetings. The 6G SNS will be expected, in turn, to host some of these international meetings.

In all cases the 6G SNS results should be accessible and available to be promoted. Moreover, the CSA should strive to see that they can adopted in an uncomplicated way.

Expected Outcome

The following expected outcomes should be addressed:

On activities within Europe:
- Constituency building, stakeholder support, support to key international cooperation events; dissemination, support to core international cooperation activities, to relevant stakeholder events; definition of future R&I actions.
- Established dialogues with Peer Partnerships (e.g., HPC, KDT, AI, Data and Robotics, Photonics Europe, etc.) and Associations (e.g., 5GAA, 5GACIA, ECH Alliance, ERTICO, ECSO etc.) and organization of dedicated workshops to ensure relevance and synergies in both directions
- Increasing the active engagement of diverse vertical sectors in order to better integrate their individual requirements
- Establishment of a continuous dialogue among the key actors taking part in Horizon Europe programme and those in the other regions programmes to reinforce collaboration and increase synergies.

On global activities:
- Creation of a global 6G ecosystem engaging relevant initiatives and key actors from EU and the other regions/countries, collaborating on the evolution of 6G.
- Reinforcement of strategic partnerships between EU and the other regions/countries for the definition of joint R&I actions in 6G areas of mutual interest through roadmapping.
- Development of 6G synergies with other Countries and Regions, incl. Japan, China, South-Korea, United States, Brazil, India, Taiwan, Russia, leveraging 5G Infrastructure PPP Global 5G Events (G5GE) experience.
- Preparation of interoperability and roaming between Europe and the rest of the world.
- Identification of specific local use-cases not usual in Europe that could have an impact on the network, including developing countries.
- A mapping of the European 6G KPI to the 6G indicators of the other global regions.
- A high level of European participation in the Global 6G events

Generally:
- Organization of workshops and other support activities to facilitate the coordination of research and innovation initiatives, and to promote collaboration between the research groups.

- A close working relationship with the SNS coordination and support CSA
- A *strong cooperation with the operational process of the private Member of the JU, notably in support of R&I, events and stakeholder management at large having an international dimension*

Scope

The proposed CSA shall liaise with the SNS RIA and IA actions under Streams A to D and the JU Office to exploit synergies for:

- Creation and implementation of a strategic promotion program for the European 6G SNS Initiative
- Promoting the 6G SNS initiative views to assert European leadership in the area across the wider community of 6G SNS stakeholders including:
  - National & Regional authorities,
  - Peer research initiatives (ESA, Eureka, etc.),
  - Peer Industrial Associations (e.g., 5GAA, 5GACIA, ECH Alliance, ERTICO, ECSO etc.),
  - The Smart Connectivity DIH Network (SCoDIHNet)
  - European and Global standards communities and
  - Global 6G discussions.
- International cooperation support with key third countries. It includes identification of international cooperation strategies with clear benefits to EU industrial stakeholders.
- Support the organisation of key conferences and dissemination events and in particular events launched by the MoU agreements between the Global regional organisations.

Appendix 1: Conditions of the 2022 Call

Call identifier: H2022-SNS-JU-2022

Publication date: January 2022

Type of call: single stage call

Indicative deadline: april 2022 17:00:00 (Brussels local time)

Indicative budget: EUR 240 million

Estimated value of the In-Kind contributions to Operational Activities (IKOP) by the members other than the Union or their constituent entities: Minimum EUR 12 million. A minimum programme level IKOP contribution of 5% is targeted and proposals are expected to significantly contribute to this target (see section 1.4).

In Kind Contribution to Operational Activities (IKOP) are defined in Article 2 (8) of EU Council regulation establishing the Joint Undertakings under Horizon Europe[18] as follows:

in-kind contributions to operational activities means contributions by private members, constituent entities or the affiliated entities of either, by international organisations and by contributing partners, consisting of the eligible costs incurred by them in implementing indirect actions less the contribution of that joint undertaking and of the participating states of that joint undertaking to those costs;

Target for SME participation is at 20% at programme level. Proposals are expected to contribute to this target, see section 1.4.

Indicative budgets by type of actions

Topic	Indicative Budget (€ million)
Research and Innovation Actions (RIA)	
STREAM A	
SNS-2022-STREAM-A-01-01	EUR 6 Million
SNS-2022-STREAM-A-01-01	EUR 6 Million
SNS-2022-STREAM-A-01-01	EUR 6 Million
SNS-2022-STREAM-A-01-01	EUR 6 Million
SNS-2022-STREAM-A-01-01	EUR 6 Million
SNS-2022-STREAM-A-01-01	EUR 6 Million
SNS-2022-STREAM-A-01-01	EUR 6 Million
STREAM B	
SNS-2022-STREAM-B-01-01	EUR 24 Million
SNS-2022-STREAM-B-01-02	EUR 30 Million

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[18] https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf

SNS-2022-STREAM-B-01-03	EUR 25 Million
SNS-2022-STREAM-B-01-04	EUR 20 Million
SNS-2022-STREAM-B-01-05	EUR 23 Million
STREAM C	
SNS-2022-STREAM-C-01-01	EUR 25 Million
Innovation Actions (IA)	
STREAM D	
SNS-2022-STREAM-D-01-01	EUR 46 Million
Coordination and Support Actions (CSA)	
SNS-2022-STREAM-CSA-01	EUR 3 Million
SNS-2022-STREAM-CSA-02	EUR 2 Million
Total	EUR 240 Million

Indicative timetable for the evaluation and grant agreement

Information on the outcome of the evaluation	Indicative date for the signing of grant agreements
Maximum 5 months from the final date for submission	Maximum 8 months from the final date for submission

1. Call management rules

The SNS JU operates under the Horizon Europe Rules for Participation, set out in Regulation (EU) (EU) 2021/695 of the European Parliament and of the Council of 28 April 2021 laying down the rules for participation and dissemination in "*Horizon Europe - the Framework Programme for Research and Innovation (2021-2027)*" and repealing Regulation (EU) No 1290/2013 and (EU) No 1291/2013 (EC) and (EU) No 1291/2013

1.1. Admissibility

Part A of the General Annexes to the Horizon Europe Work Programme 2021-2022 shall apply *mutatis mutandis* to the call covered by this Work Plan, with the following derogations to page limits:

The limit for a full application is **70 pages for RIA's** submitted under Streams A and C and for IA's submitted under Stream D

The limit for a full application is **100 pages for RIA's** submitted under Stream B

The limit for a full application is **70 pages for submission of CSA's**

1.2. Eligibility

Part B of the General Annexes to the Horizon Europe Work Programme 2021-2022 shall apply *mutatis mutandis* to the call covered by this Work Plan, with the following derogation:

In application of Article 5.2.(a) of the EU Council decision 2021/2085 outlining the Single Basic Act establishing the SNS Joint Undertaking, the following restrictions apply:

Actions	Restriction	Justification	Note
SNS-2022-STREAM-B-01-05	The call is restricted to the SNS JU member other than the Union and their constituent or affiliated entities	The **flagship project** will represent the European vision of 6G and its strategic nature goes beyond R&D work. It needs to be established and steered with long term commitment of partners and from the JU member other than the Union.	
SNS-2022-STREAM-C-01-01	The call is restricted to the SNS JU member other than the Union and their constituent or affiliated entities	The projects will establish the **programmatic large scale platform for test and validation** of critical technologies and will be enhanced over the JU life time. This needs a long term commitment of the participating entities and from the JU member other than the Union.	Opening is established at 20% of the budget to incorporate specific actors on an ad-Hoc basis through later third party financing (cascading grants)
SNS-2022-STREAM-D-01-01	The call is restricted to the member other than the Union and their constituent or affiliated entities	The projects will leverage and **complement the programmatic large scale platform for test and validation** of critical technologies and will be enhanced over time. This needs a long-term commitment of the	Opening is established at 40% of the budget to incorporate specific actors on an ad-Hoc basis through later third party

		participating entities and from the JU member other than the Union.	financing (cascading grants)	

For the above conditions, **a self-declaration** will be requested at proposal stage.

1.3. Financial and operational capacity and exclusion

Part C of the General Annexes to the Horizon Europe Work Programme 2021-2022 shall apply *mutatis mutandis* to the call covered by this Work Plan

1.4. Award criteria

Part D of the General Annexes to the Horizon Europe Work Programme 2021-2022 shall apply *mutatis mutandis* to the call covered by this Work Plan with the following complements:

For RIA's under Streams A and B, the award criteria table is complemented with a sub criterion in the impact section reflecting the relevance for proposals to contribute to the overall IKOP objectives of the call. (text in italic in the below table). Relevant proposals are expected to credibly contribute to the overall 5% IKOP objectives[19].

For RIA's under Streams A, B and C, and for IA's under stream D, the award criteria table is complemented with a sub criterion in the impact section reflecting the target SME participation.

Only relevant instruments for the call are reported here.

	Excellence (The following aspects will be taken into account, to the extent that the proposed work corresponds to the description in the work programme)	**Impact**	**Quality and efficiency of the implementation**
Research and innovation actions (RIA) **Innovation actions (IA)**	- **Clarity and pertinence of the project's objectives, and the extent to which the proposed work is ambitious and goes beyond the state of the art.**	- **Credibility of the pathways to achieve the expected outcomes and impacts specified in the work programme, and the likely scale and**	- Quality and effectiveness of the work plan, assessment of risks, and appropriateness of the effort assigned to work packages, and the resources overall.

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[19] **NB :** For these Streams the target IKOP corresponds to participation of Member other than the Union or their affiliated entities at an average level of about 33%.

	- **Soundness of the proposed [for the first stage: overall] methodology,** including the underlying concepts, models, assumptions, inter-disciplinary approaches, appropriate consideration of the gender dimension in research and innovation content, and the quality of open science practices, including sharing and management of research outputs and engagement of citizens, civil society and end-users where appropriate.	**significance of the contributions from the project.** - Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities. *- Extent to which the members of the proposed consortium contribute to the expected level of in-kind contribution to operational activities to help reaching the target additional investments* *- SME Participation and opportunities to leverage project results.*	- Capacity and role of each participant, and the extent to which the consortium as a whole brings together the necessary expertise.
Coordination and support actions (CSA)	- **Clarity and pertinence of the project's objectives.** - **Quality of the proposed coordination and/or support measures, including soundness of methodology.**	- **Credibility of the pathways to achieve the expected outcomes and impacts specified in the work programme, and the likely scale and significance of the contributions from the project.** - Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and	- Quality and effectiveness of the work plan, assessment of risks, and appropriateness of the effort assigned to work packages, and the resources overall. - Capacity and role of each participant, and the extent to which the consortium as a whole brings together the necessary expertise.

		exploitation plan, including communication activities.	

1.5. Documents

Part E of the General Annexes to the Horizon Europe Work Programme 2021-2022 shall apply *mutatis mutandis* to the call covered by this Work Plan.

1.6. Procedures

Part F of the General Annexes to the Horizon Europe Work Programme 2021-2022 shall apply *mutatis mutandis* to the call covered by this Work Plan with the following precision:

When two RIA proposals are equally ranked and that it has not been possible to separate them using first the coverage criterion, second the excellence criterion, and third the generic Impact criterion, the level of SME participation will be taken as the next criterion to sort out the ties and if still un-conclusive, the level of IKOP will be considered as appropriate.

1.7. Legal and financial set-up of the grant agreements

Part G of the General Annexes to the Horizon Europe Work Programme 2021-2022 shall apply *mutatis mutandis* to the call covered by this Work Plan

1.8. Specific conditions for actions implementing pre-commercial procurement or procurement of innovative solutions

Part H of the General Annexes to the Horizon Europe Work Programme 2021-2022 is not applicable to the call covered by this Work Plan

1.9. Other Specific Conditions

The following additional conditions shall apply for the call covered by this work plan:

i) **Project collaboration.**

The project contracted under this call will be expected to enter into a collaboration agreement to collectively work on topics of mutual interests. To that end, they will be subject to contractual clause outlined in article 7 of the Model Grant Agreement

ii) **Security provisions applicable to Stream D**

In order to meet the security requirements specified under Stream D above, all proposals submitted, shall have to include security declarations, which demonstrate that the network technologies and equipment (including software and services) in the proposed project comply with relevant security requirements and in particular, indicate that required documents, information and results related to equipment or services deployed or used within the proposed project will be duly protected and not lead to exposure of sensitive information in the cybersecurity context to entities not established in Member States or controlled from third countries. As part of the security declaration the proposal shall contain information that:

(a)   Demonstrates that the infrastructure deployed within the proposed project shall remain, during the action and for a specified period after its completion, within the beneficiary/beneficiaries and shall not be subject to control or restrictions by entities not established in Member States or controlled from third countries.

(b)   Demonstrates that for any equipment to be deployed for the implementation of the proposed project and/or used for the management and operation of the resulting digital connectivity infrastructure, the required documents, information and results will be duly protected and not exposed to entities not established in Member States or controlled from third countries. This should in particular apply to suppliers of equipment as well as suppliers of relevant services.

Based on this security declaration by the proponent, as well as the evaluation carried out by independent experts, the Commission (or funding body) may require security measures to be implemented in the project and/or carry out a security scrutiny focusing on the exchange of project information, documents and results considered as security-sensitive information among project partners.

iii)   **Third party funding (cascading grants)**

Cascading Grants/third party funding is planed for following actions under this call:

- SNS-2022-STREAM-C-01-01, RIA implemented under Stream C: 20 % of the budget will be reserved for third party financing;

- SNS-2022-STREAM-D-01-01, IA implemented under Stream D: 40 % of the budget will be reserved for third party financing;

For these actions, the third party financing contractual clause of **Article 6 D.1 of the MGA will apply**.