Destination 4: Digital & Emerging Technologies for Competitiveness and Fit for the Green Deal

This destination will directly support the following Key Strategic Orientations (KSOs), as outlined in the 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

Proposals for topics under this Destination should set out a credible pathway to contributing to the following expected impact:

- **Open strategic autonomy 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.

Electronic and photonic components, and the software that defines how they work, are the key digital technologies that underpin all digital systems. As the digitalisation of all sectors accelerates, most industries depend on early access to digital components. Dependence on these technologies represents a clear threat to Europe's autonomy, particularly in periods of geopolitical instability, exposing Europe to risks of vulnerability. Actions under this Destination will build on EU strengths in low-power consumption and ultra-secure components, Europe needs to develop the essential electronic and photonic components for a wide range of applications such as healthcare equipment, electric and autonomous vehicles, manufacturing and production plants and equipment, telecom networks, aerospace vehicles, consumer products

R&I initiatives on 6G technologies are now starting in leading regions world-wide, with the first products and infrastructures expected for the end of this decade. 6G systems are expected to offer a new step change in performance from Gigabit towards Terabit capacities and sub-millisecond response times, to enable new critical applications such as real-time automation or eXtended Reality ("Internet of Senses"). Europe must engage now to be among the top influencers of - and competitors in - these technologies and ensure that emerging network technology standards are defined following European values and energy-efficiency requirements. Main actions on 6G technologies will be undertaken in the Smart Networks and Services Joint Undertaking.

Despite a strong European scientific community's on AI and robotics, Europe lags behind in AI diffusion. Actions under this Destination will develop world-class technologies serving the needs of all types of European industries (e.g. manufacturing, healthcare, transport, agriculture, energy, construction), providing top-performing solutions that businesses will trust and adopt to maintain their competitiveness and maximise their contribution to environmental sustainability.

While Europe is strong in many sectors, it must take ownership of its unavoidable future transformations for competitiveness, prosperity and sustainability, by early leadership in new and emerging enabling technologies, e.g. alternative computing models such as bio- and neuro-morphic approaches, use of biological elements as part of technology, and sustainable smart materials. In particular, the far-reaching impact of quantum and graphene technologies on our economy and society cannot be fully estimated yet, but they will be disruptive for many fields. Actions in this Destination will ensure that Europe stays ahead in this global race and is in a position to achieve game-changing breakthroughs.

In line with the vision set out in the Digital Decade Communication (COM(2021)118), in particular its 'secure and performant sustainable digital infrastructures' pillar, actions under this Destination will support Europe's open strategic autonomy, and reinforce and regain European industry's leaderships across the digital supply chain. It will direct investments to activities that will ensure a robust European industrial and technology presence in all key parts of a greener digital supply chain, from low-power components to advanced systems, future networks, new data technologies and platforms. Autonomy will require sustaining first-mover advantage in strategic areas like quantum computing and graphene, and investing early in emerging enabling technologies.

Investments in this Destination contribute substantially to climate change objectives. Energy efficiency is a key design principle in actions, which will lead to new technologies and solutions that are cornerstones for a sustainable economy and society. These solutions range from ultra-low-power processors to AI, Data and Robotics solutions for resource optimisation and reduction of energy consumption and CO2 emissions; from highly efficient optical networking technologies and ultra-low-energy 6G communication networks to robotics that overcome the limitation of energy autonomy. Furthermore, promising emerging avenues are addressed via ultra-low power operations enabled by spintronics and 2D materials-based devices and systems for energy storage and harvesting.

Actions should devote particular attention to openness of the solutions and results, and transparency of the research and innovation process. To ensure trustworthiness and wide adoption by user communities for the benefit of society, actions should promote high standards of transparency and openness. Actions should ensure that the processes and outcomes of research and innovation align with the needs, values and expectations of society, in line with Responsible Research and Innovation.

As a result, this Destination is structured into the following headings, which group topics together with similar outcomes to address a common challenge:

- European Innovation Leadership in Photonics

The European photonics industry has an excellent position in core segments, far above the average EU market share. The objective of the topics grouped in this heading is to strengthen current leadership in photonic technologies and applications, and to secure access in Europe to cutting-edge photonic technologies.

The topics of this heading are under the co-programmed Partnership 'Photonics'.

- AI, Data and Robotics

Europe has an outstanding track record in key areas of AI research, Europe's scientific community is leading in AI and robotics, but substantial efforts are needed to transform this into (disruptive) European AI technology products that can withstand international competitors. Europe also lags behind in technology diffusion, less than half of European firms have adopted AI technology, with a majority of those still in the pilot stage. 70% of these adopter companies, only capture 10% of full potential use, and only 2% percent of European firms in healthcare are using those technologies at 80% of potential [225]. Moreover, as demonstrated during the COVID-19 crisis, many AI, Data and Robotics solutions exist today but only a limited number of them reaches the level of maturity and adoption necessary to solve the problems at hand. Therefore, there is room for improved adoption by industry, which requires a drastic increase of industry-driven R&I, from basic research to large-scale piloting. In general, industry acknowledges the potential of AI technologies, but often lacks demonstrable benefits for their particular use cases.

The objective of this heading is to ensure autonomy for Europe in AI, data and robotics in developing world-class technologies serving the needs of all types of European industries, from manufacturing to healthcare, public sector, utilities, retail, finance, insurance, transport, agriculture, energy, telecommunications, environmental monitoring, construction, media, creative and cultural industries, fashion, tourism, etc. providing top-performing solutions that industries will trust and adopt to maintain their competitiveness and maximise their contribution to environmental and resources sustainability.

Several topics of this heading are under the co-programmed Partnership 'AI, Data and Robotics'.

When it comes to Robotics, Europe is leading in its industry, with a high intensity of use of robots. Europe is also scientifically leading in robotics' cognition, safety, manipulation, soft robotics, underwater and aerial robotics, with demonstrated impacts in many use-cases in key industrial sectors (e.g.: healthcare, agri-food [226], forestry, inspection and maintenance, logistics, construction, manufacturing, etc.) and across multiple modalities (aerial, marine, ground, in-vivo and space).

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225 See https://www.mckinsey.com/featured-insights/artificial-intelligence/tackling-europes-gap-in-digital-and-ai (based on data from 2017 and 2018)

226 The term Agri-Food is intended to cover a wide range of food production sectors including livestock farming, fisheries, horticulture etc., as well as produce processing, ingredient preparation and food manufacture and assembly.

The objective of this heading is to ensure autonomy for Europe in robotics, leading the way in research, development and deployment of world-class technologies.

Several topics of this heading are under the co-programmed Partnership 'AI, Data and Robotics'.

- Open Source for Cloud/Edge and Software Engineering Fundamentals to support Digital Autonomy

The European strategy for data (COM(2020) 66) aims at creating a single market that will ensure Europe's global competitiveness and data sovereignty. This calls for the ability to handle the entire data life-cycle which in turn relies on the underlying computing infrastructure (from the hardware to the software).

In the light of dominant players, bridging established computing models (High Performance Computing, Cloud Computing, edge-computing and other emerging computing architectures) becomes a critical success factor for enabling a computing continuum. Open computing architectures at many levels based on Open approaches spanning both software/hardware is thus a pre-requisite for Digital autonomy – notably when it comes to Cloud infrastructures where European players are falling short.

Actions under this heading will thus support the next steps of development and adoption of Open technologies on different levels while fostering progress on responsible software engineering fundamentals.

- European leadership in Emerging and Enabling Technologies

Europe's leading industry sectors have a solid track-record in constant improvement, but less so for embracing transformative ideas. The pathway from research to industry uptake is often long and staged, with no intertwining of research and industry agendas. In the age of deep-tech, though, this intertwining is essential.

The objective of this heading is to identify early technologies that have the potential to become Europe's future leading technologies in all areas of this cluster and to establish industry leadership in these technologies from the outset. This heading has a unique focus on off-roadmap transformations with a longer time-horizon but profound potential impact.

- Flagship on Quantum Technologies: a Paradigm Shift

Since 2018, the Quantum Technologies Flagship has been consolidating and expanding Europe's scientific leadership and excellence in quantum, in order to foster the development of a competitive quantum industrial and research ecosystem in Europe. The EU's aims for quantum R&I in the next decade are set out in detail in the Quantum Flagship's Strategic Research Agenda (SRA[227]) and its associated main Key Performance Indicators, which drafted and published in 2020 on quantum computing, quantum simulation, quantum communication, and quantum sensing and metrology. Projects in each of these areas are

[227] https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=65402

currently supported by the Flagship, by other EU research initiatives and by national programmes.

The objective of this heading is to further develop quantum technologies and their applications in the areas of quantum computing, simulation, sensing and communication, in order to strengthen European technological sovereignty in this strategic field and achieve first-mover industry leadership, capitalising on Europe's established excellence in quantum science and technology maintaining and developing quantum competences and skills available in the EU and raising the capabilities of all Member States in this field.

The aim of the Commission's Digital Decade strategy is for the EU to become digitally sovereign in an interconnected world, and in the coming years quantum technologies will be a key element of this digital sovereignty, as they are of global strategic importance. Quantum technologies will be also used, among others, for sensitive applications in the area of security, and in dual-use applications. Other world regions are already investing heavily in all areas of quantum technologies research. In this context, the EU must take action to build on its strengths, and to carefully assess and address any strategic weaknesses, vulnerabilities and high-risk dependencies which put at risk the attainment of its ambitions. This will enable it to safeguard its strategic assets, interests, autonomy and security, while advancing towards its goal of open strategic autonomy.

The Quantum Technologies Flagship conducts research and development activities in the key domains of quantum computing and simulation, quantum communication, and quantum sensing. The Flagship will contribute to world-leading quantum computers and simulators, that will be acquired by the European High Performance Computing Joint Undertaking, and will be crucial to achieving its Digital Decade goal of having its first computer with quantum acceleration by 2025, with a view to being at the cutting edge of quantum capabilities by 2030. These machines will have a profound impact, with applications in medicine, manufacturing, or new material and new drugs design but also in cryptography, finance and many other sensitive domains.

Research in quantum sensing technologies is also vital to the EU's interests, as it will develop European expertise in quantum clocks for navigation (including for embarkation on Galileo satellites) and precise timing applications, sensors for autonomous vehicles, and the next generation of medical sensors.

It is therefore clearly in the EU's interests to protect European research in these domains, the intellectual property that it generates, and the strategic assets that will be developed as a result, while taking steps to avoid situations of technological dependency on non-EU sources (in line with the call of the October 2020 European Council to reduce Europe's strategic dependencies). With this in mind, the Commission has decided that, in the research areas covered by 6 actions in this work programme in quantum computing and simulation, communication, and sensing, only Associated Countries that meet certain conditions will be eligible to participate in these actions.

The eligibility to participate in such actions is limited to specific entities as specified in the relevant topics.

- Graphene: Europe in the lead

The starting point is the Graphene Flagship, launched in 2013, which already reached European leadership in graphene and related 2D materials. The work is now coming to a critical point where first simple products are being launched. R&I activities would now need to be pursued and accelerated in order to translate achieved technology advances that are at TRL 3-5 into concrete innovation opportunities and into production capabilities in many industrial sectors (e.g. aviation, automotive, electronics, batteries, healthcare).

The objective of this heading is to strengthen and accelerate the technology developments that support a strong European supply and value chain in graphene and related materials and provide first-mover market advantages of scale.

Activities beyond R&I investments will be needed to realise the expected impacts: testing, experimentation, demonstration, and support for take-up using the capacities, infrastructures, and European Digital Innovation Hubs made available under the Digital Europe Programme; large-scale roll-out of innovative new technologies and solutions (e.g. new energy-efficient connectivity technologies) via the Connecting Europe Facility; further development of skills and competencies via the European Institute of Innovation and Technology, in particular EIT Digital; upscaling of trainings via the European Social Fund +; and use of financial instruments under the InvestEU Fund for further commercialisation of R&I outcomes.

Expected impact

Proposals for topics under this Destination should set out a credible pathway to contributing to **digital and emerging technologies for competitiveness and fit for the Green Deal**, and more specifically to one or several of the following impacts:

- Europe’s open strategic autonomy by sustaining first-mover advantages in strategic areas including AI, data, robotics, quantum computing, and graphene, and by investing early in emerging enabling technologies.
- Reinforced European industry leadership across the digital supply chain.
- Robust European industrial and technology presence in all key parts of a greener digital supply chain, from low-power components to advanced systems, future networks, new data technologies and platforms.

Innovation Actions — Legal entities established in China are not eligible to participate in Innovation Actions in any capacity. Please refer to the Annex B of the General Annexes of this Work Programme for further details.

The following call(s) in this work programme contribute to this destination:

Call	Budgets (EUR million)		Deadline(s)
	2023	2024	
HORIZON-CL4-2023-DIGITAL-EMERGING-01	108.00		29 Mar 2023
HORIZON-CL4-2023-DIGITAL-EMERGING-01-CNECT	129.00		29 Mar 2023
HORIZON-CL4-2024-DIGITAL-EMERGING-01		136.50	19 Mar 2024
HORIZON-CL4-2024-DIGITAL-EMERGING-01-CNECT		88.00	19 Mar 2024
Overall indicative budget	237.00	224.50	

Call - Digital and emerging technologies for competitiveness and fit for the Green Deal

HORIZON-CL4-2023-DIGITAL-EMERGING-01

Conditions for the Call

Indicative budget(s)[228]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[229]	Indicative number of projects expected to be funded
		2023		
Opening: 08 Dec 2022 Deadline(s): 29 Mar 2023				
HORIZON-CL4-2023-DIGITAL-EMERGING-01-01	RIA	30.00 [230]	Around 8.00	4
HORIZON-CL4-2023-DIGITAL-EMERGING-01-12	RIA	22.00	5.00 to 7.00	4
HORIZON-CL4-2023-DIGITAL-EMERGING-01-51	RIA	18.00 [231]	3.00 to 5.00	4
HORIZON-CL4-2023-DIGITAL-EMERGING-01-53	RIA	18.00 [232]	3.00 to 5.00	4
HORIZON-CL4-2023-DIGITAL-EMERGING-01-57	IA	20.00 [233]	5.00 to 7.00	4
Overall indicative budget		108.00		

228 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2023 and 2024.

229 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

230 Of which EUR 10.50 million from the 'NGEU' Fund Source.

231 Of which EUR 7.20 million from the 'NGEU' Fund Source.

232 Of which EUR 7.20 million from the 'NGEU' Fund Source.

233 Of which EUR 8.00 million from the 'NGEU' Fund Source.

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

AI, Data and Robotics (incl. efficient, robust, safe, adaptive and trusted robots)

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-01: Novel paradigms and approaches, towards AI-driven autonomous robots (AI, data and robotics partnership) (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 8.00 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 30.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may

	additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcome(s):

- Achieve substantial "next step autonomy" in robots, undertaking non-repetitive tasks in realistic settings, including Human-Robot interactions, as well as robots acting in isolation, demonstrated in key high impact sectors where robotics has the potential to deliver significant economic and/or societal benefits. This next step autonomy should clearly delineate from state of the art solutions and can be illustrated by the following non-exhaustive examples[234]:

    - In autonomy to reach the point where the robot systems, operating in complex and dynamic working environments can autonomously select the tasks and task sequences that are needed to achieve long term mission goals over long periods of autonomous operation, relative to the current state of the art, and are able to react and adapt to changes in both the environment and to the external instructions received from unskilled or semi-skilled human users. For example in being able to carry out maintenance tasks on a structure after having conducted an inspection to ascertain the type of maintenance needed (e.g. on renewable energy installations such as wind turbines, photovoltaic farms, or in the maintenance of city infrastructure such as wastewater systems or road and rail infrastructures).

    - In human interaction to reach the point where robots are able to autonomously adapt in order to socially interact with people in an everyday working environment in order to achieve task outcomes through intuitive interaction that is multi-modal; by voice, physical, gestural etc. and to collaboratively achieve complex tasks that require multiple functional capabilities where humans and robots contribute equally to those capabilities. For example in complex healthcare tasks such as patient handling or in complex logistical operations such as the optimal packing of consumer goods for shipping.

    - In manipulation, to be able to achieve more complex manipulative tasks autonomously, requiring advanced perception and task understanding, as well as adaptive planning to anticipate possible changes in the environment during task execution. Robotic manipulation systems should target speed and dexterity with respect to a wide range of different objects and materials.

Projects are also expected to contribute to the following additional outcomes:

- Deliver a step change in autonomy essential for the diffusion of robots in various industries, sectors and services which can;

[234] In these descriptions the word adapt is used in a general sense and refers to the alteration of behaviours and goals by any means.

- o interact safely and smoothly to support humans in their daily activities, based on strong multidisciplinary approach, including the relevant Social Science and Humanities (SSH) dimension,
- o handle tasks autonomously, and safely, for a long periods of time significantly beyond the current state of the art in each sector and service addressed,
- o address human and work interaction in high impact sectors under realistic conditions.

- Accelerate enabling conditions essential for the diffusion of robots in various industries, sectors and services.

Make and exploit major advances in science and technology, to maintain Europe's scientific excellence and ensure sovereignty of key technologies in robotics and autonomous systems expected to affect society by contributing to addressing major societal and economic challenges.

Scope: The currently low level of autonomy achieved by most robotics systems is a major obstacle to the wide-scale deployment of robots with advanced capabilities in many real-world applications. Most robots still require an important level of human supervision. However, in many potentially valuable applications robots need to work with greater levels of autonomy to create effective end user added value.

Future robotic systems will be required to autonomously adapt and alter their behaviours to respond to changes in the working environment and adjust to changes in task requirements without direct human supervision.

Achieving next step autonomy in robotics will require greater integration of AI technologies into the physical functioning of robots. This in turn requires AI to operate in real time at pace with the physical motion of the robot. Interpreting the working environment, interacting with complex objects or people and making and updating decision making, all in real time, requires a significant advance from the current state of the art. This will require novel architectures both in software and hardware and will require AI algorithms compatible with physical, real time, robot operation. In terms of R&I advancement a paradigm shift is needed to remove silos between disciplines in order to weld together expertise and create a conceptual shift to reach the goals of next step autonomy for robotics.

The primary outcome will be that important applications for robots become possible as a result of achieving next step autonomy in specific use cases and sectors.

Achieving this goal will require improvements in perception, awareness of the operating environment, the ability to anticipate and an improved understanding of the consequences of particular sequences of action on the working environment.

Proposals will need to address safety and security aspects at all levels, as well as consider the handling of data collection (respecting relevant regulation such as the GDPR and the revised Machinery Directive).

Proposals should address the interdependence between safety, security and system performance with respect to the chosen application or use case.

Proposals should address several of the following aspects of autonomy:

- Long-term, and where appropriate lifelong, autonomy of behaviour and energy (including frugality in terms of energy, lower environmental footprint, using new materials, designed to be recycled or easily repaired etc.)
- The autonomous adaptation of behaviours in dynamic environments.
- The development of robust and safe autonomy, including the development of risk averse systems or systems operating with low levels of communication or periods of communication denial.
- The use of high-level sources of information such as semantic information or externally held knowledge of the working environment, to improve autonomy.
- Mechanisms for advanced human interaction with systems capable of long-term autonomy.
- The impact of physical self-reconfiguration on autonomy
- The development of collective autonomy using multiple collaborative robots

Multidisciplinary research activities should address all of the following:

- Proposals should involve appropriate expertise in all relevant disciplines. Social Sciences and Humanities (SSH) is particularly relevant in addressing aspects related to human-robot interaction, sensible task distribution between humans and robots, agency, control, trust and handling of data collection, to achieve usability, trustworthiness, safety and adoption of the developed solutions.
- It is essential that scientific and technological results should bear reproducible and re-usable in order to contribute to the advancement of the targeted research area.
- S&T progress should be demonstrated through use-cases with major and broad socio-economic impact.
- End-users should be involved, as scenario providers, to set the requirements, success criteria and context, for the targeted sectors and/or use-cases that inform the technological challenges to be addressed in the projects.
- Projects should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives.

- Contribute to making AI and robotics solutions meet the requirements of Trustworthy AI, based on the respect of the ethical principles, the fundamental rights including critical aspects such as robustness, safety, reliability, in line with the European Approach to AI. Ethics principles needs to be adopted from early stages of development and design.

All proposals are expected to embed mechanisms to assess and demonstrate progress (with qualitative and quantitative KPIs, benchmarking and progress monitoring, as well as illustrative application use-cases demonstrating well defined potential added value to end-users), and share communicable results with the European R&D community, through the AI-on-demand platform or Digital Industrial Platform for Robotics, public community resources, to maximise re-use of results, either by developers, or for uptake, and optimise efficiency of funding; enhancing the European AI, Data and Robotics ecosystem through the sharing of results and best practice.

This topic implements the co-programmed European Partnership on AI, data and robotics.

European Leadership in Emerging and Enabling Technologies

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-12: Adaptive multi-scale modelling and characterisation suites from lab to production (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 5.00 and 7.00 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 22.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to start at TRL 3 and achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Enable industry to more effectively develop new and work with existing advanced materials by building on digitally integrated and validated modelling and characterisation methods for enhanced materials knowledge along value chains.

- Accelerate the materials innovation process by allowing a better interpretation of available experimental data and by providing more effective guidance on further experiments.

- Overcome gaps in modelling and characterisation capabilities targeted at different stages in materials and production value chains by means of adapted and benchmarked suites covering all steps from materials design (including several scales, e.g. from molecular to macroscale) to product development.

- Achieve an integrated European materials platform,[235] allowing a systemic use of tools and capabilities including materials modelling, characterisation, robotics, data documentation, ontologies, artificial intelligence and machine learning, which are orchestrated to accelerate the design, development and application of chemicals, materials and related processes and manufacturing.

Scope: To support the green and digital industrial transition, there is the need to develop innovative routes to accelerate the design and production of new advanced materials, improving the circular economy and developing alternative feedstocks to support the EU's open strategic autonomy throughout value chains (and covering all aspects of sustainability). Industrial research for materials from laboratory to production requires the extension of current knowledge on materials behaviour to the entire value chain.

To tackle this challenge, we can build on European leadership in recent advances in multi-scale modelling and characterisation.

The development of novel advanced materials requires a wide and complex range of trusted information on materials and process behaviour, along the entire life-cycle of a material, reaching far beyond the data sets generally available to industry currently. In particular, an approach is required that provides end users with highly flexible, adaptable modelling and characterisation tools as a source of data and knowledge in critical application fields. Subsequently, the validation of the developed methods will help industry to establish trust in these methods. This will also support the emerging need for adopting alternative materials as feedstock compliant with the high qualification standards and strengthen the strategic autonomy and resilience of EU's industry.

Proposals should address the development of benchmarked, integrated suites of models and characterisation methods for critical application fields in strategic innovation markets covering the different stages in materials and industrial production value chains and circularity.

In particular, proposals should address all of the following:

- Develop integrated methodologies of multi-scale and multi-technique characterisation, combined with respective multi-scale modelling and machine learning to

    - improve the reliability and quality of data;

    - understand scaling relationships in the behaviour of advanced materials;

235 https://ec.europa.eu/info/sites/default/files/research_and_innovation/research_by_area/documents/advanced-materials-2030-manifesto.pdf

- develop complex structure-property correlations in advanced materials;
- ensure complete coverage of conditions in industrial environments.

- Integrate modelling and characterisation, in particular by
  - Developing modelling methods that provide the capabilities to virtually characterise materials and enhance the interpretation of the results of particular characterisation methods in order to guide and refine experiments;
  - Developing accurate, validated physics-based models, in areas where these capabilities are a bottleneck, by utilising a combination of characterisation and machine learning to generate material and application specific parameters and equations (called materials relations, ref. CWA 17284[236]).
- Demonstrate the functionality of the suites for the development of certain advanced materials for the green transition.
- Validate the methodologies and provide benchmarks, i.e. clear documentation of capabilities that can serve as a standard point of reference for industrial application.

Research should build on existing standards or contribute to standardisation. Documentation and interoperability for data sharing should be addressed, based on the OntoCommons EcoSystem (OCES).

Projects should build on and seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes and platforms. In particular, projects funded under this call should collaborate under the umbrella of the EMMC and EMCC and interact closely with topic HORIZON-CL4-2023-RESILIENCE-01-39 (CSA).

European Innovation Leadership in Photonics

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-51: Pervasive photonics - multi-technology integration for digital infrastructure, sensors and internet of things (Photonics partnership)(RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 3.00 and 5.00 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

236 https://www.cencenelec.eu/media/CEN-CENELEC/CWAs/RI/cwa17284_2018.pdf

Indicative budget	The total indicative budget for the topic is EUR 18.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 2 and achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to at least three of the following outcomes:

Improved key metrics for communications (speed, power consumption, density) or for sensing (sensitivity, compactness, power consumption), making photonics ubiquitous in digital systems

New photonic-enabled sensing functions, not feasible with a technology platform based on a single material, or computing paradigms enabling new systems architectures (e.g. neuromorphic computing)

Vital contribution to Technological Sovereignty, Green Deal, Digital Transformation or Competitiveness which demonstrates new functionality, higher performance and more cost-effective systems across multiple application domains

Maintaining European technology leadership in the face of strong global competition

Scope: Proposals should address one of the following areas of activities:

- Co-integration of photonics and microelectronics on single or multiple die (‘chiplet’ approach)
- Co-integration of multiple photonic IC material systems or components to address new wavelengths and sensor functions or new computing paradigms

Proposals should demonstrate at least two use cases linked to commercial applications for example in computing, communications, robotic and autonomous systems, sensors or Internet of Things.

This topic implements the co-programmed European Partnership Photonics.

HORIZON-CL4-2023-DIGITAL-EMERGING-01-53: Versatile light sources and systems as tools for manufacturing and medical application (Photonics Partnership) (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 3.00 and 5.00 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 18.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to start at TRL 2 and achieve TRL 5 by the end of the project – see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [237].

Expected Outcome: Projects are expected to contribute to at least two of the following outcomes:

- Outcome 1: Increased manufacturing productivity or increased quality and speed of diagnosis results;
- Outcome 2: Increased accuracy and/or reduced feature size in microelectronics production including packaging for the integration of photonic and electronic functionalities on chips;
- Outcome 3: Increased specificity of diagnosis of human tissue, specific single cells, or molecular biomarkers in body liquids.

Scope: Proposals should address new versatile light sources and lasers, concept and systems for extended and new fields of applications. Research challenges include:

[237] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf

- Sources with multi-specification / multi-application potential;
- Extended or new wavelength ranges, novel coherent sources;
- Flexible and variable energy deposition (e.g. material processing, medical diagnosis) ;
- Versatility by flexible pulse shapes, repetition rates and intensities (cw down to fs and bursts);
- Miniaturized light sources and lasers employing photonic integrated circuit technology
- Versatility by spectral tuneability, coherence and multi-wavelength emission;
- Laser concepts and systems for multiphoton microscopy, spectroscopy and imaging.

The results and benefits of the developed technologies should be demonstrated in at least two realistic use cases.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

This topic implements the co-programmed European Partnership Photonics.

HORIZON-CL4-2023-DIGITAL-EMERGING-01-57: Advanced imaging and sensing technologies (IA)(Photonics Partnership)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 5.00 and 7.00 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 20.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to start at TRL 3 and achieve TRL 6-7 by the end of the project – see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: The funding rate is up to 60% of the eligible costs. This funding rate applies to both members and non-members of the partnership, except for non-profit legal entities, where the funding rate is up to 100% of the total eligible costs.

	Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [238].

Expected Outcome: Projects are expected to contribute to the following outcomes:

- The development of next generations sensory systems based on photonic technologies
- Technology leadership in autonomous vehicles, robots and sensory systems; Growth in a number of strategic industries such as medical devices, automotive, manufacturing, agriculture & food, security of large added value which are in Europe.
- Contribution to the Digital Green deal policy and/or to the technological sovereignty of Europe.

Scope: Innovative hardware and software approaches, or to explore novel techniques with potential to outperform the current standards.

The projects should demonstrate the technology in the form of complete function (or building blocks) showing feasibility for future industrialisation.

It should address the following sectors:

- Automotive, where detection of pedestrians, obstacles and other vehicles at long distance is required in order to safely prepare the reaction of the vehicle in all weather conditions;
- Safety and security, where fast reconnaissance and identification of collaborative or non-collaborative targets and surveillance of infrastructures are required;
- Industry, where imaging can be used for logistics and inspection and analysis of safety and quality control of processes or produced goods;
- Health, where minimally and non-invasive spectroscopic and biophotonic imaging and sensing techniques enable diagnosis, screening, monitoring and treatment of a patient, possibly including augmented reality (AR) visualization;
- Agriculture and food, where spectroscopic imaging and sensing enables non-destructive measurement/monitoring of plants and crops and plant nutrients during production and post-harvest (e.g., phenotyping); this allows fast interactions/adjustments and enables

[238] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf

monitoring of plant materials and food products along the entire production chain for quality and safety aspects.

Technologies covering more than one application sectors above are encouraged, such as:

- Long range, high speed, eye-safe imaging for automotive, security, and industrial systems
- Imaging in presence of obscurants for medical, automotive, manufacturing, agriculture, food and security, spectroscopic imaging and sensing for medical, environmental, agriculture, food monitoring and security.

This topic implements the co-programmed European Partnership Photonics.

Call - Digital and emerging technologies for competitiveness and fit for the Green Deal

HORIZON-CL4-2023-DIGITAL-EMERGING-01-CNECT

Conditions for the Call

Indicative budget(s)[239]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[240]	Indicative number of projects expected to be funded
		2023		
Opening: 08 Dec 2022 Deadline(s): 29 Mar 2023				
HORIZON-CL4-2023-DIGITAL-EMERGING-01-02	IA	30.00 [241]	Around 10.00	3
HORIZON-CL4-2023-DIGITAL-EMERGING-01-11	RIA	35.00	3.00 to 4.00	10
HORIZON-CL4-2023-DIGITAL-	RIA	6.00 [242]	3.00 to 5.00	2

239 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2023 and 2024.

240 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

241 Of which EUR 10.50 million from the 'NGEU' Fund Source.

EMERGING-01-32				
HORIZON-CL4-2023-DIGITAL-EMERGING-01-33	RIA	12.00 [243]	3.00 to 4.00	3
HORIZON-CL4-2023-DIGITAL-EMERGING-01-40	RIA	12.00 [244]	4.00 to 6.00	2
HORIZON-CL4-2023-DIGITAL-EMERGING-01-41	RIA	20.00 [245]	7.00 to 12.00	2
HORIZON-CL4-2023-DIGITAL-EMERGING-01-43	FPA			0
HORIZON-CL4-2023-DIGITAL-EMERGING-01-50	RIA	10.00 [246]	2.00 to 3.00	3
HORIZON-CL4-2023-DIGITAL-EMERGING-01-56	CSA	4.00 [247]	1.00 to 3.00	2
Overall indicative budget		129.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant	The rules are described in General Annex G.

242 Of which EUR 2.10 million from the 'NGEU' Fund Source.
243 Of which EUR 4.20 million from the 'NGEU' Fund Source.
244 Of which EUR 4.20 million from the 'NGEU' Fund Source.
245 Of which EUR 7.00 million from the 'NGEU' Fund Source.
246 Of which EUR 3.50 million from the 'NGEU' Fund Source.
247 Of which EUR 1.40 million from the 'NGEU' Fund Source.

Agreements	

AI, Data and Robotics (incl. efficient, robust, safe, adaptive and trusted robots)

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-02: Industrial leadership in AI, Data and Robotics – advanced human robot interaction (AI Data and Robotics Partnership) (IA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 10.00 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 30.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 3-5 and achieve TRL 6-7 by the end of the project – see General Annex B.
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio coverage, grants will be awarded to applications not only in order of ranking but at least also to the highest ranked proposal for each of the two expected scopes (1. Development of innovative solutions to address major application-driven challenges, 2. Large scale pilots bringing major industries from key application sectors in Europe). Proposals should clearly identify the scope it will focus on.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries may provide financial support to third parties. The support to third parties can only be provided in the form of grants.

	As third parties' grants may include robotics components, requiring high equipment investment and/or important effort to integrate in a use-case to address robotics challenges, the maximum amount to be granted to each third party is EUR 200 000.

Expected Outcome: Projects are expected to contribute to all the following outcomes:

- To reach the point where human robot interaction, extended in time and scope beyond the current state of the art, adds value and improves the quality of outcome for complex tasks; for example service tasks, or complex industry processing tasks or tasks in a healthcare setting. Where the focus is on tasks where robotics can add capabilities that extend human ability but which require human interaction to be achieved. These tasks will require varying levels of interaction and communication, dependent on the current state of the task, but will essentially require close interaction over extended periods of time.

- Validate AI, Data and Robotics at scale by demonstrating the potential of integrating these technologies to address challenges in key industries and develop solutions that address human robot interaction at all levels from physical interaction to social interaction in a variety of working environments.

- Make and exploit major advances in technology, to maintain Europe’s excellence and ensure sovereignty of these key technologies expected to affect society by contributing to addressing major societal challenges by enhancing interactions between robots and people. Boost the innovation potential for wide uptake of AI, Data and Robotics by significantly improving the ability of robots to work in collaboration with humans as equals.

Scope: Proposals should demonstrate the added value of integrating AI, Data and Robotics technologies through large-scale validation scenarios reaching critical mass and mobilising the user industry, Focus should be given to attracting new user industries, to boost the uptake of AI, Data and Robotics in major sectors and stimulate the involvement of end-users where appropriate. Besides major industries, these Actions should also involve SMEs and/or start-ups with high potential to foster innovation that advances the nature and level of interaction between people and robots, especially dealing with paradigmatic shifts in working practice that create improvements for industry and society. Proposals should target sectors and application domains with wide-scale deployment potential and maximum contribution to the European economy.

Multidisciplinary innovation activities should address one of the following:

- Development of innovative solutions to address major application-driven challenges, involving a large set of SMEs/ midcaps developing innovative solutions in order to boost the innovator community in Europe. This action also aims to expand the deployment of software engineering dedicated to human robot interaction. Especially to extend and

adopt the practices of the Digital Industrial Platform for Robotics, and to stimulate the development of robust middleware that can be deployed in service and industrial applications and to expand the number and variety of high quality sharable industrially deployable modules related to human robot interaction at all levels, fostering the widespread deployment of such technologies in the targeted application sector and beyond.

Financial Support to Third Parties: Projects should use FSTP to stimulate the engagement of SMEs in the delivery of high quality, robust, sharable modules for use in human robot interaction in service and industrial tasks. Minimum 50% of the EU funding requested by the proposal should be allocated to the purpose of financial support to third parties.

- Large scale pilots bringing major industries from key application sectors in Europe – facilitating collaboration between these major companies and innovative SMEs/Start-ups/academia/tech-transfer organisations with the goal is to exploit re-usable tools, systems, sub-systems and solutions in various use-cases/sectors where human robot interaction is a critical necessity. Pilots should show scalability/versatility, and enable economies of scale.

Financial Support to Third Parties: Projects may involve FSTP in order to stimulate the engagement of SMEs in testing and validating innovative solutions in the pilots. A maximum of 50% of the EU funding requested by the proposal may be allocated to the purpose of financial support to third parties.

Proposals should involve appropriate expertise in all the relevant disciplines, such as engineering, computer sciences, mathematics, Social Sciences and Humanities (SSH), neuroscience, psychology, cognitive sciences, philosophy, biology, etc. and in particular should involve the relevant expertise to address the human factors aspects of robot human collaboration at all levels of interaction.

Proposals should clearly delineate the expected contributions from the main beneficiaries as well as from the third parties, to ensure their coherence and impact.

Security, privacy and safety should be taken into account to minimise risks to users both in terms of physical harm and in terms of digital privacy and security.

Proposals should include a clear business case and exploitation strategy.

Proposals should contribute to making human robot interactions using AI and robotics solutions meet the requirements of Trustworthy AI, based on the respect of the ethical principles, the fundamental rights including critical aspects such as robustness, safety, reliability, in line with the European Approach to AI. With these principles being adopted from the early stages of development and design through to deployment by using appropriate models of human robot interaction.

Proposals are expected to embed mechanisms to assess and demonstrate progress (with qualitative and quantitative KPIs, benchmarking and progress monitoring, as well as

illustrative application use-cases demonstrating well defined added value to end users), and share communicable results with the European R&D community, through the robotics elements of the AI-on-demand platform and/or the Digital Industrial Platform for Robotics, public community resources, to maximise re-use of results, either by developers, or for uptake, and optimise efficiency of funding; enhancing the European AI, Data and Robotics ecosystem through the sharing of results and best practice.

This topic implements the co-programmed European Partnership on AI, data and robotics.

European Leadership in Emerging and Enabling Technologies

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-11: Low TRL research in micro-electronics and integration technologies for industrial solutions (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 3.00 and 4.00 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 35.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 1-2 and achieve TRL 3-4 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Innovative semiconductor and micro-nanoelectronic systems design concepts supporting very low energy consumption, integrated security, connectivity, sensing, actuating and embedded functions suited to mixed analogue/RF and digital circuits.

- Alternative[248] semiconductor manufacturing process technologies able to sustain in the mid- and long-terms the fast pace evolution of device performance, miniaturisation and cost, while reducing environmental footprint.

- Very advanced packaging solutions aiming at extreme miniaturisation and integration of multiple functions such as communication (RF, mmW or THz), sensing, actuating, power management and active/passive integration

Scope: Proposals should:

- Address low-TRL research with high potential not yet demonstrated in the design, fabrication process and/or packaging segments of the micro-nano-electronics and integration technologies value chain.

- Innovation focus can be on materials, physic concepts, device architecture or integration technologies.

- Provide a projection of the expected gains and main figures of merit of the proposed approaches.

Multi-disciplinary research activities should be address along part of the value chain from materials, processes, equipment, metrology, back-end processing to packaging, integration and tests.

International cooperation is encouraged, especially with leading semiconductor countries (e.g. Japan, South Korea, Taiwan) in support of EU policies (and outcome of the CSA on Int' cooperation in SC).

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

Graphene and 2D materials: Europe in the lead

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-32: Sustainable safe-by-design 2D materials technology (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 3.00 and 5.00 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 6.00 million.

248 Alternative to mainstream Silicon CMOS technologies

Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project – see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [249].

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Development of Safe and Sustainable by Design two-dimensional materials (2DM) technology.
- Societal acceptance of 2DM and 2DM-based technologies.
- A set of robust and verified assays for toxicity and eco-toxicity testing of 2DM, to support regulatory requirements for their registration and authorisation for use (OECD test guidelines[250], REACH compliance, authorisation pathways[251])

Scope: The increasing commercial exploitation of 2DM necessitates a comprehensive evaluation of their potential impact on human health and the environment. It is thus of utmost importance for 2DM technology development to understand the properties that underlie the potential toxicity of these materials. Since not all 2DMs are alike, it is essential to disentangle the structure-activity relationships for this class of materials.

Proposals should aim to ensure a safe development of 2DM technology and in the long term, a sustainable market entry/penetration of 2DM-based products. Proposals should comply with the Safe and Sustainable by Design framework[252] and criteria.

Multidisciplinary research and innovation activities should address all of the following:

- Critical examination of 2DM health and environment issues, ranging from general toxicology, to occupational health and environmental impact.

249 This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf

250 https://www.oecd.org/chemicalsafety/testing/oecd-guidelines-testing-chemicals-related-documents.htm

251 https://echa.europa.eu/en/regulations/reach/registration

252 See documents defining the SSbD framework and criteria on: https://ec.europa.eu/info/research-and-innovation/research-area/industrial-research-and-innovation/key-enabling-technologies/advanced-materials-and-chemicals_en

- Studies and tests of biocompatibility and safety of 2DMs and composites along their life cycle;
- Development of solutions to modulate potential risks by developing appropriate chemical/physical approaches towards safer manufactured materials and nanomaterials (safe-by-design 2DMs).
- Assessing the safety of 2DMs and composites at different TRL levels to develop and test best practices along the product development process, from prototypes to products tested in relevant environments in order to guarantee the highest impact possible.
- Development of validation processes supporting regulatory assessment.

Proposals submitted under this topic should include an exploitation strategy, as outlined in the introduction to this Destination.

Research should build on existing standards or contribute to standardisation. Interoperability for data sharing should be addressed.

Proposals should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes and platforms. In particular projects are expected to develop synergies and relate to activities and outcomes of the projects selected under the other topics of 'Graphene and 2D materials: Europe in the lead' and where relevant of HORIZON-CL4-2023-RESILIENCE-01-21/22/23/24.

Proposals should also cover the contribution to the governance and overall coordination of the Graphene Flagship initiative.

Proposals should indicate which chapters of the Strategic Research and Innovation Plan for chemicals and materials they will contribute to.

Proposals should consider involving, directly or indirectly, appropriate expertise in other disciplines, for example in SSH disciplines, where relevant to achieve wider societal acceptance of 2DM-based technologies.

HORIZON-CL4-2023-DIGITAL-EMERGING-01-33: 2D materials of tomorrow (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 3.00 and 4.00 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 12.00 million.
Type of Action	Research and Innovation Actions

Technology Readiness Level	Activities are expected to start at TRL 2 and achieve TRL 4 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

A broad portfolio of innovative two-dimensional materials (2DM), networks and multicomponent hetero-structures exhibiting new properties or complementary functionalities that will lead to breakthroughs in digital systems and devices.

Scope: Proposals should create the basis for the exploitation of most promising 2DM and developed 2DM technologies.

Proposals should develop high-quality 2DM and hetero-structures platforms by exploiting most promising emerging 2DM and/or discovering new ones, and combining them in functional systems and hetero-structures. This should be achieved by pushing the boundaries of growth, characterisation methods, deposition and layer-by-layer assembly of atomically thin crystals supported by multiscale theoretical modelling of materials and devices.

Multidisciplinary research and innovation activities should address all of the following:

- Identification and demonstration of new properties and physical phenomena such as those based on the twist degree of freedom, and processes enabling new functionalities, and their implementation in proof-of-principle digital devices;
- Development of new characterisation methods and of controlled, ultra clean and large-scale synthesis, fabrication methods and design of 2D materials and hetero-structures based on novel approaches e.g. Artificial Intelligence assisting material assembly and material simulation, robotics-based assembly, and advanced synthetic, preparation and growth methods combined with the help of modelling and simulation.

Proposals should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes and platforms. In particular, projects are expected to develop synergies and relate to activities and outcomes of the projects selected under the other topics of ‘Graphene and 2D materials: Europe in the lead’.

Proposals should also cover the contribution to the governance and overall coordination of the Graphene Flagship initiative.

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

Flagship on Quantum Technologies: a Paradigm Shift

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-40: Quantum Photonic Integrated Circuit technologies (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 4.00 and 6.00 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 12.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, and security, it is important to avoid a situation of technological dependency on a non-EU source, in a global context that requires the EU to take action to build on its strengths, and to carefully assess and address any strategic weaknesses, vulnerabilities and high-risk dependencies which put at risk the attainment of its ambitions. For this reason, participation is limited to legal entities established in Member States, Iceland and Norway and the following additional associated country: Israel[253]. For the duly justified and exceptional reasons listed in the paragraph above, in order to guarantee the protection of the strategic interests of the Union and its Member States, entities established in an eligible country listed above, but which are directly or indirectly controlled by a non-eligible country or by a non-eligible country entity, may not participate in the action unless it can be demonstrated, by means of guarantees provided by their eligible country of establishment, that their participation to the action would not negatively impact the Union's strategic, assets, interests, autonomy, or security [254]

253 Legal entities established in Israel are eligible to participate in this action on the basis that (i) Israel is an associated country (and continues to be on the date of the opening of this topic for submission); and (ii) Israel meets specific conditions. Prior to the adoption of this Work Programme, questionnaires were sent to non-EEA associated countries and countries in the process of association in order to assess their eligibility to participate.

254 The guarantees shall in particular substantiate that, for the purpose of the action, measures are in place to ensure that:
a) control over the applicant legal entity is not exercised in a manner that retrains or restricts its ability to carry out the action and to deliver results, that imposes restrictions concerning its infrastructure, facilities, assets, resources, intellectual property or know-how needed for the purpose of the action, or that undermines its capabilities and standards necessary to carry out the action;

Technology Readiness Level	Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project – see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [255].

Expected Outcome: Photonic Integrated Circuits (PIC) technologies on one side and quantum science on the other are the building blocks for development of Quantum PIC (QPIC) devices for quantum information processing, computation/simulation, communication, sensing or metrology. Photon-based approaches can address the huge challenge of implementing quantum processes in public infrastructures, challenging industry applications and compact everyday-life devices and products.

QPIC technology has great potentials to target several application fields, in particular, but not limited to, health care, communications, environment and security, and thus has high strategic significance and major implications for the European economy.

However, to implement QPICs, research challenges have to be faced throughout the value chain, going from materials, circuit design (including the support of EDA tools), manufacturing processes and technological platforms, to the realization and validation of reliable and robust demonstrators and prototypes, and their integration and packaging. Furthermore, quantum systems are typically large, complex and costly, hindering their scalability, and thus cannot be directly used in products.

QPIC technology can address these issues, paving the way for compact, high performance, reliable, cost-effective components, that will enable quantum technology to be introduced in the market.

Expected Outcome:

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b) access by a non-eligible country or by a non-eligible country entity to sensitive information relating to the action is prevented; and the employees or other persons involved in the action have a national security clearance issued by an eligible country, where appropriate;
c) ownership of the intellectual property arising from, and the results of, the action remain within the recipient during and after completion of the action, are not subject to control or restrictions by non-eligible countries or non-eligible country entity, and are not exported outside the eligible countries, nor is access to them from outside the eligible countries granted, without the approval of the eligible country in which the legal entity is established.

255 This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf

- To improve over existing PIC technologies in terms of performance, functionality, manufacturing process efficiency and reliability, integration, and packaging in a manner that facilitates scalable manufacturing.

- To demonstrate the technology capability in key enabling Quantum PIC technologies with high potential impact on the quantum technology Industry, including applications in quantum sensing, communications, computation and simulation,

- Preparing QPIC technologies for future Pilot Lines and Photonics hubs and open testing and experimentation facilities,

- Exploit the potential of QPICs for a digital, green and healthy future in Europe by providing critical components and systems for next generation applications, products and processes. Develop tools for efficient design and prototyping of QPICs.

- Secure Technological Sovereignty for Europe by maintaining leadership in QPICs

- Contribution to the objectives of Digital Transformation, Green Deal, Competitiveness and Economic Growth.

Scope: Proposals will address technology (up to TRL 4-5) in key enabling PIC technology applied to market needs. Objectives include:

- Enhancement of PIC performance, e.g. ultra-low loss; ultra-low laser linewidth; ultra-high extinction ratio modulators and switches , extending spectral and optical power coverage, optical coupling interfaces, packaging.

- Incorporation of specific quantum functionality into PIC platforms, e.g. single photon and entangled photon pair generation, single photon and photon number detection , quantum memory elements, quantum processors.

- Multi-technology integration, e.g. incorporation of ion/atomic traps and relevant control electronics, superconducting detectors, nonlinear elements, integration of photonic readout into quantum computing and sensing devices employing other technologies (e.g. electronic, spintronic), relevant passive and active linear optical elements (e.g. modulators, shifters, switches etc.) to underscore a strategy for modular QPIC design.

- Development of PICs capable of operating at cryogenic temperatures, with low power dissipation and performance optimized in the context of the operating environment.

- Development of the most promising methods for QPIC fabrication in monolithic, hybrid or heterogeneous integration techniques for different functionalities together with an identification of the most advantageous platform materials, (e.g. derived from “classical” PIC technologies such as Si, SiO2, Si3N4, InP, LiNbO3, Si-on-insulator, LiNbO3-on-insulator, Al2O3, AlN, hybrid platforms, etc. etc. etc.).

- Assembly and packaging of PICs, taking the specific challenges of quantum systems (environment, temperature, stability, visible and ultraviolet wavelengths requirements,

vacuum integration) into account and including integration of complementary and ancillary technologies (e.g. microelectronics) where required

- Miniaturization of previously non-scalable quantum photonic systems by implementing them in PIC form.

Proposals should identify applications in quantum sensing, communication, computation and simulation. Proposals should test and evaluate the developed Quantum PIC technologies in the context of such specific applications though trials at systems level in a representative laboratory or an operational environment.

These technologies should be developed in a manner to facilitate scalable manufacturing. Proposals should address IP management strategy and collaboration with European industry and SMEs, in particular in the context of establishing relevant European industrial manufacturing capabilities.

Collaboration with the Quantum Flagship initiative and the photonics partnership is crucial to be able to merge knowledge and experience in photonic technologies and quantum science.

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

HORIZON-CL4-2023-DIGITAL-EMERGING-01-41: Investing in alternative quantum computation and simulation platform technologies (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 7.00 and 12.00 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 20.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, and security, it is important to avoid a situation of technological dependency on a non-EU source, in a global context that requires the EU to take action to build on its strengths, and to carefully assess and address any strategic weaknesses, vulnerabilities and high-risk dependencies which put at risk the attainment of its ambitions. For this reason, participation is limited to legal entities established in Member States, Iceland and Norway and the following additional

	associated country: Israel[256]. For the duly justified and exceptional reasons listed in the paragraph above, in order to guarantee the protection of the strategic interests of the Union and its Member States, entities established in an eligible country listed above, but which are directly or indirectly controlled by a non-eligible country or by a non-eligible country entity, may not participate in the action unless it can be demonstrated, by means of guarantees provided by their eligible country of establishment, that their participation to the action would not negatively impact the Union's strategic, assets, interests, autonomy, or security [257]
Technology Readiness Level	Activities are expected to start at TRL 3-4 and achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Proposals are expected to further mature alternative and promising quantum computation and simulation platforms which have the prospects of high scalability and programmability, to complement the ones already supported by the Quantum Technologies Flagship.

Scope: In order to reach large-scale quantum computation and simulation in Europe, breakthroughs in scalability of quantum processors and simulators, devices and integrated platforms are needed, together with the ability to perform all necessary operations of the quantum systems to have a fully programmable quantum computer or simulator. Breakthroughs in scalability need to be achieved along with breakthroughs in fidelity.

The development of alternative quantum computer and simulator systems and platforms, based for example on photonic or nitrogen vacancy-centre platforms or hybrid systems, should be integrating the key building blocks such as individual quantum systems (i.e. >10 qubits for a quantum computer and >50 quantum units for a quantum simulator), control

256 Legal entities established in Israel are eligible to participate in this action on the basis that (i) Israel is an associated country (and continues to be on the date of the opening of this topic for submission); and (ii) Israel meets specific conditions. Prior to the adoption of this Work Programme, questionnaires were sent to non-EEA associated countries and countries in the process of association in order to assess their eligibility to participate.

257 The guarantees shall in particular substantiate that, for the purpose of the action, measures are in place to ensure that:
a) control over the applicant legal entity is not exercised in a manner that retrains or restricts its ability to carry out the action and to deliver results, that imposes restrictions concerning its infrastructure, facilities, assets, resources, intellectual property or know-how needed for the purpose of the action, or that undermines its capabilities and standards necessary to carry out the action;
b) access by a non-eligible country or by a non-eligible country entity to sensitive information relating to the action is prevented; and the employees or other persons involved in the action have a national security clearance issued by an eligible country, where appropriate;
c) ownership of the intellectual property arising from, and the results of, the action remain within the recipient during and after completion of the action, are not subject to control or restrictions by non-eligible countries or non-eligible country entity, and are not exported outside the eligible countries, nor is access to them from outside the eligible countries granted, without the approval of the eligible country in which the legal entity is established.

electronics, quantum software stack, use case applications, etc. Work should address the scalability towards large systems (>100 qubits for a quantum computer and >1000 quantum units for a quantum simulator), the verification and validation of the quantum computation or simulation, solving a concrete problem to demonstrate the quantum advantage. In addition, quantum computation platform should explore fault-tolerance.

Proposals should also cover:

1. Cooperation with the complementary projects launched specifically in the area of the enabling quantum software stack (see HORIZON-CL4-2021- DIGITAL-EMERGING-02-10: Strengthening the quantum software ecosystem for quantum computing platforms), and future Digital Europe Programme EuroHPC JU calls for acquisition and operation of quantum computers, and their integration with the HPC and data infrastructure, including also the need to establish from the beginning of this cooperation appropriate IP exploitation agreements;

2. Cooperation and coordination with the Flagship initiatives supporting the establishing of key European fabrication processes, technologies and supply chain for the proposed platform, including the FPA(s) funded under HORIZON-CL4-2021-DIGITAL-EMERGING-02-17 and HORIZON-CL4-2021-DIGITAL-EMERGING-02-15 and their respective SGA(s).

3. Any additional support they may receive from relevant national, or regional programmes and initiatives; and

4. Contribution to the governance and overall coordination of the Quantum Technologies Flagship initiative. They should also contribute to spreading excellence across Europe, for example, through the involvement of EU Widening Countries.

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

HORIZON-CL4-2023-DIGITAL-EMERGING-01-43: Framework Partnership Agreement for developing large-scale quantum Computing platform technologies (FPA)

Specific conditions	
Type of Action	Framework Partnership Agreement
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, and security, it is important to avoid a situation of technological dependency on a non-EU source, in a global context that requires the EU to take action to build on its strengths, and to carefully assess and address any strategic weaknesses, vulnerabilities and

	high-risk dependencies which put at risk the attainment of its ambitions. For this reason, participation is limited to legal entities established in Member States, Iceland and Norway and the following additional associated country: Israel[258]. For the duly justified and exceptional reasons listed in the paragraph above, in order to guarantee the protection of the strategic interests of the Union and its Member States, entities established in an eligible country listed above, but which are directly or indirectly controlled by a non-eligible country or by a non-eligible country entity, may not participate in the action unless it can be demonstrated, by means of guarantees provided by their eligible country of establishment, that their participation to the action would not negatively impact the Union's strategic, assets, interests, autonomy, or security [259]
Technology Readiness Level	Activities are expected to start at TRL 4-5 and achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: The Framework Partnership Agreement (FPA) in quantum computing is expected to establish a stable and structured partnership between the Commission and the institutions and organisations in quantum computing who commit themselves to establishing, maintaining and implementing a strategic research roadmap aligned with and contributing to the Quantum Flagship Strategic Research Agenda in a scalable open quantum computing platform based on a specific quantum platform technology.

This partnership will be set up through a FPA, which will enable the completion of the research roadmap within the context of the agreement.

258 Legal entities established in Israel are eligible to participate in this action on the basis that (i) Israel is an associated country (and continues to be on the date of the opening of this topic for submission); and (ii) Israel meets specific conditions. Prior to the adoption of this Work Programme, questionnaires were sent to non-EEA associated countries and countries in the process of association in order to assess their eligibility to participate.

259 The guarantees shall in particular substantiate that, for the purpose of the action, measures are in place to ensure that:
a) control over the applicant legal entity is not exercised in a manner that retrains or restricts its ability to carry out the action and to deliver results, that imposes restrictions concerning its infrastructure, facilities, assets, resources, intellectual property or know-how needed for the purpose of the action, or that undermines its capabilities and standards necessary to carry out the action;
b) access by a non-eligible country or by a non-eligible country entity to sensitive information relating to the action is prevented; and the employees or other persons involved in the action have a national security clearance issued by an eligible country, where appropriate;
c) ownership of the intellectual property arising from, and the results of, the action remain within the recipient during and after completion of the action, are not subject to control or restrictions by non-eligible countries or non-eligible country entity, and are not exported outside the eligible countries, nor is access to them from outside the eligible countries granted, without the approval of the eligible country in which the legal entity is established.

The consortia responding to the call may include research institutes, universities, RTOs, foundations, industry, SMEs as well as other organisations that can play a role in the realisation of these quantum computing platforms. The FPA will specify the objectives, the nature of the actions planned, and the procedure for awarding specific grants. The FPA is expected to contribute to the following outcomes:

- Demonstrate a universally programmable processor of at least 200 physical qubits (by 2027) operating in the NISQ domain including firmware and having sufficient coherence to perform computations involving all of its qubits; characterised with a hardware-agnostic test suite, including real-world applications, including for hybrid quantum/HPC computing, and the capability of out-performing classical computers on a number of relevant real-world use-cases; control needs to involve a low-level control system, a compiler and a scheduler.

- By 2029, build a full stack, highly connected, high fidelity quantum computer of at least one thousand physical qubits, exhibiting scalability and capable of out-performing classical computers on relevant real-world use-cases.

- Formulate standards and interface specifications for a complete software and hardware stack including remote, cloud-based access.

Scope: Fostering a vibrant European quantum computing industry will require hardware, software, and the development and maintenance of user interfaces and applications. Proposals for this FPA are expected to build on the quantum computing platforms supported under the Quantum Flagship ramp-up phase. Proposals should target the development of open quantum computing platforms compatible with the fabrication techniques of the semiconductor industry (e.g. silicon spin qubits), integrating the key building blocks such as quantum processors in the NISQ regime with control electronics, low-level software, verification and validation of the quantum computation, etc.

Proposals should include practical strategies towards the break-even point of fault tolerance to increase algorithmic depth (number of operations) for quantum computing on existing platforms.

Proposals for the FPA should describe how the activities carried out during the ramp-up phase will be continued involving the relevant disciplines ,technologies and stakeholders, how results of the ramp-up phase will be used, and how they will provide efficient coordination under strong scientific and engineering leadership.

Proposals for the FPA should also address the development and integration in this platform of a full software stack, including a compiler and scheduler, programming tools, a suite of algorithms, use cases etc., that would allow them to showcase their capability of solving real and concrete computational problem(s) that demonstrate a quantum advantage and to make progress towards fault tolerance.

Proposals should aim at the development of open quantum computer experimental systems, and work on the reduction of their form factor.

Proposals for FPAs should also cover: (i) the cooperation with complementary projects previously launched, specifically in the area of the enabling quantum software stack (see HORIZON-CL4-2021-DIGITAL-EMERGING-02-10: Strengthening the quantum software ecosystem for quantum computing platforms), and DEP Future EuroHPC JU Calls for acquisition and operation of Quantum computers, and their integration with the HPC and data infrastructure, including also the need to establish from the beginning of this cooperation appropriate IP exploitation agreements; (ii) the collaboration with other initiatives or programmes at regional, national, transnational or global level; (iii) any additional support they may receive in their activities from relevant national, or regional programmes and initiatives; and (iv) contribution to the governance and overall coordination of the Quantum Technologies Flagship initiative. (v) relevant aspects of cooperation with European industry and SMEs/ They should also contribute to spreading excellence across Europe; for example, through the involvement of Widening Countries.

The partnership will have a duration of 4 years.

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

HORIZON-CL4-2023-DIGITAL-EMERGING-01-50: Next generation quantum sensing and metrology technologies (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 2.00 and 3.00 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 10.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, and security, participation in this topic is limited to legal entities established in Member States, associated countries, OECD and Mercosur countries. Proposals including legal entities which are not established in these countries will be ineligible. This decision has been taken on the grounds that, in the area of research covered by this topic, EU open strategic autonomy is particularly at stake. It is important to avoid a situation of technological dependency on a non-EU source, in a global context that requires the EU to take action to build on its strengths, and to carefully assess and address any strategic

	weaknesses, vulnerabilities and high-risk dependencies which put at risk the attainment of its ambitions. For the duly justified and exceptional reasons listed in the paragraph above, in order to guarantee the protection of the strategic interests of the Union and its Member States, entities established in an eligible country listed above, but which are directly or indirectly controlled by a non-eligible country or by a non-eligible country entity, may not participate in the action unless it can be demonstrated, by means of guarantees provided by their eligible country of establishment, that their participation to the action would not negatively impact the Union's strategic, assets, interests, autonomy, or security[260].
Technology Readiness Level	Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to demonstrate the feasibility of next generation quantum sensing and metrology technologies and devices by showing disruptive progress in the performance, reliability and efficiency and application of such technologies and devices and by enhancing the TRL of all (essential) components necessary to build them.

Scope: Proposals should focus on next generation quantum sensors and metrology devices such as for example quantum enhanced spectroscopy and imaging, including entangled and/or superposition-based clocks, quantum opto-mechanical sensing devices, squeezed states of light, point-defects in the solid-state (bulk or 2D materials). They are expected to provide extreme precision and accuracy measurements in many fields, beyond the performance of consumer devices and services, in applications such as for example medical diagnostics and imaging, quantum enhanced spectroscopy and imaging, entangled clocks, inertial sensors, high and quantum opto-mechanical sensing devices, radio-frequency sensing, high-precision navigation and monitoring, ultraprecise time standards in aerospace or information networks, quantum imaging and non-line-of-sight imaging, quantum communications and cryptography relevant for security, communication to future applications in the Internet of Things, hybrid

[260] The guarantees shall in particular substantiate that, for the purpose of the action, measures are in place to ensure that:
a) control over the applicant legal entity is not exercised in a manner that retrains or restricts its ability to carry out the action and to deliver results, that imposes restrictions concerning its infrastructure, facilities, assets, resources, intellectual property or know-how needed for the purpose of the action, or that undermines its capabilities and standards necessary to carry out the action;
b) access by a non-eligible country or by a non-eligible country entity to sensitive information relating to the action is prevented; and the employees or other persons involved in the action have a national security clearance issued by an eligible country, where appropriate;
c) ownership of the intellectual property arising from, and the results of, the action remain within the recipient during and after completion of the action, are not subject to control or restrictions by non-eligible countries or non-eligible country entity, and are not exported outside the eligible countries, nor is access to them from outside the eligible countries granted, without the approval of the eligible country in which the legal entity is established.

superconducting-magnetic / sensing devices, quantum imaging for material science and microelectronics.

Proposals should address: (i) the development of new methods and techniques to achieve full control over all relevant quantum degrees of freedom and to protect them from environmental noise; and/or (ii) identify correlated quantum states that outperform uncorrelated systems in a noisy environment and methods to prepare them reliably. Proposed work should exploit quantum properties (such as coherence, superposition and entanglement) emerging in quantum systems to improve the performance of the targeted sensors technologies (e.g. in terms of resolution, sensitivity or noise), well beyond the classical limits.

Proposals should target the development of laboratory prototypes (from TRL 2-3 to 4-5) demonstrating the practical usefulness of engineered quantum states of light/matter to improve sensing or imaging and develop and demonstrate optimized quantum software for detection applications in real-world applications. They should leverage interdisciplinary expertise and join forces with metrology institutes or other relevant technical fields to further advance the limits of sensors sensitivity and resolution and to implement the best control protocols, statistical techniques (e.g. Bayesian, among others) and machine learning algorithms as appropriate.

Projects should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes and platforms and contribute to the governance and overall coordination of the Quantum Technologies Flagship initiative.

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

European Innovation Leadership in Photonics

Proposals are invited against the following topic(s):

HORIZON-CL4-2023-DIGITAL-EMERGING-01-56: Photonic Strategies and Skills Development (CSA) (Photonics Partnership)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 1.00 and 3.00 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 4.00 million.
Type of Action	Coordination and Support Actions
Procedure	The procedure is described in General Annex F. The following

	exceptions apply: To ensure a balanced portfolio covering both activity areas in the scope below, grants will be awarded to applications not only in order of ranking, but also to at least one project in each activity area, provided that the applications attain all thresholds.

Expected Outcome: Projects are expected to contribute to at least one of the following outcomes:

- Reinforced value chains and deployment of photonics technologies by stronger cooperation of photonics stakeholders, clusters and end-users;
- Increased competitiveness of the European photonics sector and improved access to finance for the photonics sector in Europe;
- More and better prepared professionals in the photonics sector.

Scope: Two types of proposals are expected.

Type 1: Supporting the industrial strategy for photonics in Europe (EU contribution around 3 million EUR)**.** The objective is to support the development and implementation of a comprehensive industrial strategy for photonics in Europe. The action should include the development of strategic technology road-maps, strong stakeholder engagement (in particular Photonics21 stakeholders, National Technology Platforms, regional Clusters, end-user industries), coordination of regional, national and European strategies and priorities, fostering collaboration with other European Partnerships to identify synergies and fields of common interest, and fostering strategic collaboration with financial institutions to improve financing conditions for Photonics industry, e.g. loans for growth financing, Venture Capital.

Type 2: Fostering careers in photonics (EU contribution around 1 million EUR)**.** The objective is to reach out to STEM graduates/PhD students and young postdocs in order to encourage more of them to pursue a career in photonics. Actions should help make students more industry ready and should provide the appropriate training, encourage innovation and entrepreneurship. Action should seek synergies with the skills development activities called for in the Digital Europe programme and with the activities on strategy development called for under type 1.

This topic implements the co-programmed European Partnership Photonics.

Call - Digital and emerging technologies for competitiveness and fit for the Green Deal

HORIZON-CL4-2024-DIGITAL-EMERGING-01

Conditions for the Call

Indicative budget(s)[261]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[262]	Indicative number of projects expected to be funded
		2024		
Opening: 15 Nov 2023 Deadline(s): 19 Mar 2024				
HORIZON-CL4-2024-DIGITAL-EMERGING-01-03	RIA	30.00	Around 8.00	4
HORIZON-CL4-2024-DIGITAL-EMERGING-01-04	IA	60.00	Around 10.00	5
HORIZON-CL4-2024-DIGITAL-EMERGING-01-22	RIA	13.50	4.00 to 6.00	4
HORIZON-CL4-2024-DIGITAL-EMERGING-01-54	RIA	18.00	3.00 to 5.00	4
HORIZON-CL4-2024-DIGITAL-EMERGING-01-55	IA	15.00	Around 15.00	1
Overall indicative budget		136.50		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.

261 The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2023 and 2024.

262 Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

AI, Data and Robotics (incl. efficient, robust, safe, adaptive and trusted robots)

Proposals are invited against the following topic(s):

HORIZON-CL4-2024-DIGITAL-EMERGING-01-03: Novel paradigms and approaches, towards AI-powered robots– step change in functionality (AI, data and robotics partnership) (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 8.00 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 30.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 2-3 and achieve TRL 4-5 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to all of the following primary outcomes:

- Achieve the substantial next step in the ability of robots to perform non-repetitive functional tasks in realistic settings, based on underlying robot functions (e.g. guidance/navigation/manipulation/interaction etc.), demonstrated in key high impact sectors where robotics has the potential to deliver significant economic and/or societal benefits. This next step functionality should clearly delineate from state of the art solutions and can be illustrated by the following non-exhaustive examples that illustrate different types of functional ability. Proposals should address functional challenges that are of equivalent or greater complexity and/or combine different types of functions to deliver greater functional complexity:

    - To reach the point where the robot systems operating in harsh complex and dynamic working environments can carry out sequences of complex functions to achieve a functional goal.

    - For example a robot able to carry out a range of different types of functions where the choice and sequence of execution depends on the dynamics of the operating context as the task progresses.

    - In navigation to reliably and purposefully move between destinations within complex people centric environments that are occupied such as busy transport hubs, shopping malls or entertainment and sporting venues; or to move purposefully maintaining a direction of travel towards a target destination or sequence of destinations over variable terrain where the surface is shifting and reactive to the robot's motion for example on sand, gravel or waterlogged ground; or to be able to navigate, move purposefully and transition between water and air or water and land including mixed surfaces attaining a target destination, or sequence of destinations over extended distances beyond the current state of the art.

    - In manipulation to reach human speed with equivalent dexterity, or manipulate objects beyond human capability, such as very small objects, or very precise manipulation tasks, or vary big objects, beyond current capabilities and functionalities; to manipulate complex articulated objects either as part of an assembly task or in order to use those objects as tools to achieve a specific function. For example handling a complex articulated part while a processing operation is taking place on it; or to manipulate and assemble soft objects or materials that deform under their own weight such as textiles as a part of a useful process.

- Step change in the enabling conditions essential for the accelerated diffusion of robots in various industries, sectors and services which can 1) handle tasks efficiently, robustly, and safely and 2) interact naturally and smoothly to support humans in their daily activities, based on a strong multidisciplinary approach, including the relevant SSH dimension.

- The development, use and exploitation of major advances in science and technology for the enhancement of European robotics, in order to maintain Europe's scientific excellence and ensure sovereignty of key technologies relevant to robotics

- Create opportunities to affect society in the longer term by contributing to impact on major broad societal challenges.

Scope: For robots to be usefully and efficiently deployed to perform new activities in physical interaction with the real world requires an improvement in and expansion of the range of functionalities robots can deploy.

This needs to take place in sectors where the capabilities of robots can be utilised to progress productivity in critical industries, support European industries essential for sovereignty and in sectors with high impact across Europe such as manufacturing, healthcare, agri-food, construction etc.

In particular the following major areas of functional performance need to be progressed to the next level of performance:

- significant enhancement of navigation capabilities in order to enhance mobility (underwater, on the ground, in the air, in the body, in areas difficult to reach, on rough terrain, in unpredictable environments, in areas including people or other moving agents, etc.), particularly in highly dynamic and complex environments.

- extension of manipulation capabilities to address:

    - large (of the order of metres to 10s of meters in scale), or heavy (of the order of 100kg to multiple 100kg)

    - or small objects of millimetre or centimetre scale, or smaller; ,

    - or of objects that are soft, deformable, articulated, delicate or hazardous objects;

Each of these require significant advances in precision, force, speed, re-planning, physical perception, grasping, manipulation (including bi-manual), etc.), in order to achieve beyond human capability in manipulation and dexterity.

For large scale manipulation applications include but are not limited to manufacturing, assembly, maintenance and installation of large infrastructure; for example wind turbines, energy pylons, pipelines, dwellings, industrial buildings, transport infrastructure etc.)

For small scale manipulation applications include but are not limited to medical and healthcare (human and animal), pharmaceutical and laboratory automation, process industries, materials processing and micro-fabrication and assembly.

- significant enhancement of functional interaction capabilities to deliver efficient, safe and natural interaction with people, objects, with other robots, within complex and dynamic working environments, including the ability to adapt to variation in the working environment and the needs and dynamics of users, objects and structures, etc.).

Making significant next step advances in these functional capabilities will require paradigm shifts in terms of both physical and systems architecture particularly through the removal of silos between disciplines that contribute to robotics functionalities.

Proposals will need to address safety and security aspects at all levels, as well as consider the data life cycle in line with GDPR.

Proposals should aim to address bold and significant challenges to the enhancement of robot functionality and do so by utilising multidisciplinary research activities.

Proposals should address several of the following in the context of improved functional performance relevant to deployment barriers in a high impact sector:

- Robust perception and the integration of sensing into physical structures to enhance motion and perception
- Advanced safe and reliable navigation functionalities, integrating anticipation, re-planning, high-level goal optimisation. Natural human-robot interaction functionality
- Advanced cognitive capabilities, integrating any type of learning (from experience, collaborative intelligence or learning from human knowledge, frugality in terms of data, unsupervised, etc.), modelling, reasoning, introspection, etc.
- Novel design approaches, e.g. soft robotics, under-actuated, miniaturised, modular/reconfigurable robots including those capable of self-reconfiguration, e.g. for guidance/navigation/manipulations in places hard to reach
- Mobile manipulation, natural manipulation of arbitrary objects including soft, fragile or other items complex to handle (e.g. dirty, slippery, deformable)
- Advanced navigation/manipulation in extreme environments, extremely small and precise in the body, autonomous navigation on shifting and uneven surfaces and in transition, for example between water and air or water and land, field robotics in harsh environments, the handling and manipulation of extremely large/heavy objects, etc.

Where relevant, proposals should contribute to making AI and robotics solutions meet the requirements of Trustworthy AI, based on the respect of the ethical principles, the fundamental rights including critical aspects such as robustness, safety, reliability, in line with the European Approach to AI. Ethics principles need to be adopted from early stages of development and design.

Critical to success will be the interaction of End Users in the definition of the problem domains and use cases that act as barriers to long term deployment and uptake across multiple sectors.

Multidisciplinary research activities should address all of the following:

- Proposals should involve appropriate expertise in the necessary relevant disciplines to reach their objectives. SSH is particularly relevant in addressing human aspects related to human-robot interaction, sensible task distribution between humans and robots, agency, control, trust and handling of data collection, to achieve usability, trustworthiness, safety and adoption of the developed solutions.
- It is essential that scientific and technological results are reproducible and re-usable in order to contribute to the advancement of the targeted research area.
- S&T progress should be demonstrated through use-cases with major and broad socio-economic impact.
- Projects should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes.

All proposals are expected to embed mechanisms to assess and demonstrate progress (with qualitative and quantitative KPIs, benchmarking and progress monitoring, as well as illustrative application use-cases demonstrating well-defined potential added value), and share communicable results with the European R&D community, through the AI-on-demand platform or Digital Industrial Platform for Robotics, public community resources, to maximise re-use of results, either by developers, or for uptake, and optimise efficiency of funding; enhancing the European AI, Data and Robotics ecosystem through the sharing of results and best practice.

This topic implements the co-programmed European Partnership on AI, data and robotics.

HORIZON-CL4-2024-DIGITAL-EMERGING-01-04: Industrial leadership in AI, Data and Robotics boosting competitiveness and the green transition (AI Data and Robotics Partnership)
(IA)[[https://www.europarl.europa.eu/RegData/etudes/STUD/2021/662906/IPOL_STU(2021)662906_EN.pdf]]

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 10.00 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 60.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation

	and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 3-5 and achieve TRL 6-7 by the end of the project – see General Annex B.
Procedure	The procedure is described in General Annex F. The following exceptions apply: To ensure a balanced portfolio coverage, grants will be awarded to applications not only in order of ranking but at least also to the two highest ranked proposals for each of the two expected outcomes (1. The creation of systems to address large scale challenges using combined robotics data and AI solutions, 2. The creation of systems to address large scale resource optimisation challenges using combined AI and Data solutions). Proposals should clearly identify the outcome it will focus on.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries may provide financial support to third parties. The support to third parties can only be provided in the form of grants. As third parties' grants may include robotics components, requiring high equipment investment and/or important effort to integrate in a use-case to address robotics challenges, the maximum amount to be granted to each third party is EUR 200 000. 40% budget for FSTP in sub-area 'creation of systems to address large scale resource optimisation challenges using combined AI and Data solutions'

Expected Outcome: Projects are expected to contribute to one of the two following outcomes, exclusively:

- The creation of systems to address large scale challenges using combined robotics data and AI solutions that have significant impact on the objectives of the green deal. For example; in improving domestic energy consumption or in the cleaning up of contaminated land and waterways or in accelerating the circular economy along the complete value chain through automated waste avoidance and waste processing or reuse of materials.

- The creation of systems to address large scale resource optimisation challenges using combined AI and Data solutions, that have significant impact on the objectives of the green deal, such as optimisation of any kind of resources, from production to use along

the complete value chain in order to minimise waste or foster the reuse of resources or in using AI and data solutions to maximize energy efficiency, ensuring energy security.

Which will contribute to

- The validation of solutions at scale by demonstrating the potential of integrating these technologies to address challenges in industrial ecosystems and develop solutions that are environmental friendly and contribute to the green deal
- Making and exploiting major advances in science and technology, to maintain Europe's scientific excellence and ensure sovereignty of these key technologies expected to affect the society in contributing to addressing major societal challenges affecting the environment.
- Exploring deployment solutions that can ensure efficient scale up.
- Boosting the uptake of AI, Data and Robotics to exploit the major contribution expected to environmental sustainability.

Proposals should clearly identify the outcome it will focus on.

Scope: Proposals should demonstrate the added value of integrating either AI and Data, or AI, Data and Robotics technologies through large-scale validation scenarios reaching critical mass and mobilising the user industry, while demonstrating high potential impact contributing to the European Green Deal objectives. For example in the recycling of electric car batteries, cleaning and monitoring the oceans, decommissioning energy infrastructure, supporting the recycling of materials, the optimisation of energy usage, the minimisation of resource waste in value-chains, for example through the better adaption of production to demand, etc.

Focus should be given to attracting new user industries, and/or showing new business opportunities to boost the uptake of AI, Data and Robotics in major sectors and stimulate the involvement where appropriate of end-users to define the technological barriers to uptake and the use cases for deployment.

Proposals should address the involvement of SMEs and/or start-ups with significant potential to foster innovation through their engagement with large scale pilots. Focus will be on leveraging and nurturing emerging collaborations between stakeholder communities shaping an effective eco-system fit for the challenge of European AI, Data, Robotics, and on accelerating European R&I through structural involvement of innovative SME and deep-tech start-ups.

Proposals should target sectors and application domains with wide-scale deployment potential and maximum contribution to the green deal.

Multidisciplinary innovation activities should address one of the following:

- Large scale pilots bringing major industries from key application sectors in Europe – facilitating collaboration between small and large companies with the goal of exploiting

and integrating existing tools, sub-systems and solutions that are re-usable from other sectors (thereby showing scalability/versatility, and enabling economies of scale) to have significant impact on the objectives of the green deal. The focus will be on the integration of tools, systems sub-systems and solution in the pilot by the grant beneficiaries. In this case, proposals are not expected to involve the use of financial support to third parties.

- The development of large-scale pilots addressing key applications with a significant and scalable impact on the objectives of the green deal by facilitating collaboration between small and large companies able address key challenges in the deployment of AI, Data and Robotics.

Financial Support to Third Parties: Projects should use FSTP to leverage novel technical advantage to address the operation of the pilot and to thereby support end users and service providers in addressing the challenges of the green deal. Third parties are expected to use the pilots for developing, testing and validating innovative solutions with significant impact on the green deal. Proposals should clearly delineate the expected contributions from the main beneficiaries as well as from the third parties, to ensure their coherence and impact. 40% of the EU funding requested by the proposal should be allocated to the purpose of financial support to third parties.

Proposals should either involve directly, or indirectly, appropriate expertise in other relevant disciplines for example related to environmental science and, as necessary, Social Sciences and Humanities (SSH) disciplines, especially where this is relevant to validating the effectiveness of proposed systems and technologies with respect to the green deal objectives.

Proposals should include a clear business case and exploitation strategy.

All proposals are expected to embed mechanisms to assess and demonstrate progress (with qualitative and quantitative KPIs, benchmarking and progress monitoring, as well as illustrative application use-cases demonstrating well defined added value to end users), and share communicable results with the European R&D community, through the AI-on-demand platform and/or the Digital Industrial Platform for Robotics, public community resources, to maximise re-use of results, either by developers, or for uptake, and optimise efficiency of funding; enhancing the European AI, Data and Robotics ecosystem through the sharing of results and best practice.

This topic implements the co-programmed European Partnership on AI, data and robotics.

Open Source for Cloud/Edge and Software Engineering Fundamentals to support Digital Autonomy

Proposals are invited against the following topic(s):

HORIZON-CL4-2024-DIGITAL-EMERGING-01-22: Fundamentals of Software Engineering (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 4.00 and 6.00 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 13.50 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 2 and achieve TRL 5 by the end of the project – see General Annex B.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [263].

Expected Outcome: Responsible software engineering methods, tools, and best practices leveraging, among others, novel AI and data technologies to accelerate the development and maintenance of software, including for multi-architecture systems, addressing in particular efficient and agile modelling, verification and validation, as well as vulnerability assessment and mitigation.

Scope: Proposals are expected to progress state of the art in at least one of these areas:

- Methods, mechanisms and tools that allow smart intelligent system specification, agile system and code development, advanced code analysis, fault prediction and location and

[263] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf

self-repair by using emerging techniques, in particular based on AI and data technologies. This may include environments that allow to automatically derive requirements and produce conceptual and architectural models. Tools should support mastering complex requirements, design-by-contract programming at all levels of integration, semi-automatic creation of pre-conditions, post-conditions and invariants for software modules facilitating automated unit and integration testing.

- Methods and tools for the development of dynamic and resilient software for systems running on multiple processing architectures including cross-compilation, run-time self-adaptation and multi-architecture executables.

Projects are expected to demonstrate their developments in at least three industrial or societal use-cases. Implementing responsible software engineering, the use-cases should address functional as well as non-functional requirements and principles like optimising energy usage, reducing the environmental footprint, security-by-design, and data protection.

Projects should provide a dissemination and use strategy. Research and Development should interface with relevant existing standards, where appropriate. Projects are encouraged to deliver results under Open Source licenses.

Projects should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes and platforms.

European Innovation Leadership in Photonics

Proposals are invited against the following topic(s):

HORIZON-CL4-2024-DIGITAL-EMERGING-01-54: Smart photonics for joint communication & sensing and access everywhere (Photonics Partnership) (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 3.00 and 5.00 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 18.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to start at TRL 2 and achieve TRL 5 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Sensors/probes to monitor the quality of the communication network and of photonic signals transported in the communication network
- Methods to use the network as large-scale distributed sensor
- Development of foundational optical technologies, systems and networks that provide the future access infrastructure

Scope: Proposals should address at least one of the following activity areas:

- Light-based solutions to let the communication network sense, while transporting data, for example

o To enhance the security and resilience of the network

o To make network resources more energy efficient

o To warn and protect against natural disasters, earthquakes etc.

o To monitor the infrastructure where the fibre is deployed (traffic, stress in bridges…)

- Light-based solutions to bring internet everywhere, with the most relevant access technologies

o Fiber to the home, fiber to the antenna or fiber to the sky (satellite), for example with coherent passive optical networks, free space optics, Lifi or optical beamforming and steering

o while enabling the integration of all access technologies in one system

This topic implements the co-programmed European Partnership Photonics.

HORIZON-CL4-2024-DIGITAL-EMERGING-01-55: Photonics Innovation Factory for Europe (Photonics Partnership) (IA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 15.00 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 15.00 million.
Type of Action	Innovation Actions
Technology Readiness Level	Activities are expected to start at TRL 2-5 and achieve TRL 4-7 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Substantially improved penetration of core photonics technologies into multiple end-user application domains and industry sectors, in particular through carefully selected SMEs and new start-ups with the strongest potential for high impact in terms of business growth and employment, enabling a demonstrably more competitive and technologically sovereign European industry.

- Creation of a sustainable streamlined ecosystem for photonics innovation in Europe from TRL 2-7, providing European Cross-Border Added Value with a high leveraging effect on investments made at national and regional level in photonics.

Scope: The aim is to provide a virtual factory with a flexible and open structure, allowing for a multiplicity of competitive actors and services operating as a sustainable fully integrated European ecosystem of cross-border deep innovation support in core photonics technologies for the benefit of European industry. The factory should lower the entry threshold to photonics and facilitate the broad uptake and integration of these technologies in new products and processes with high potential impact in the market and on society.

It should help speed up the deployment of proven photonics technologies within European industry in order to increase its global competitiveness, with an emphasis on technological sovereignty and resilience while also fostering strong new enterprise business growth. Care will be taken that it will not compete with existing commercial offers.

Proposals should address the following:

A streamlined virtual access, supported through a network of competence centers acting as a single consortium, to a supply chain which offers a broad range of photonics technologies that cover the entire photonics innovation spectrum from concept to commercialization (TRL2-7).

The action should create pathways from initial concept through to production, employing scalable manufacturing methods connected to pilot lines and pre-series production facilities appropriate to the market, and thereby closing the gaps in photonics value chains and unlocking investments in European manufacturing based on more complete and mature solutions.

The action needs to target primarily first users and early adopters enabling the wider uptake and deployment of core photonic technologies in innovative products and processes with strong commercial potential.

Support cases should be innovative and industrially relevant, requiring intensive cross-border collaborative expert intervention to overcome specific innovation challenges based on synergetic photonics core technologies, and should include business-related coaching activities directly linked to the innovation activities to support industrialization steps to full commercial launch as a complete value chain appropriate to the market needs.

Users and early adopters may start individual support cases at different levels of technology readiness depending on their needs: TRL 2 may be useful for researchers using photonic technologies whereas industrial users may start higher, e.g. at TRL 4 or 5. Support cases

should increase the start TRL by at least two levels. All actions taken together should cover TRL work between 2 and 7.

The action should build on relevant previous European initiatives and existing infrastructure at European and regional levels, use an appropriate quality management and impact measurement framework for the direct innovation support interventions, demonstrate a record of accomplishment in supporting industry, in particular SMEs and start-ups, with deep cross-border innovation support.

The action should provide strong linkages with established European Photonics industry and investment networks such as the Enterprise Europe Network, as well as (pan-) European Digital Innovation Hubs and cluster organizations in both the photonics and photonics-enabled application domains.

The action should address innovation-readiness support in the form of Demonstration Centers and Experience Centers to help prepare business cases plus additional supports such as technology, business, investment, and intellectual property coaching aimed at maximizing the potential future commercial impacts from the innovation support activities. The action should also be capable of demonstrating a strong business plan towards durable funding and sustainability of its activities.

This topic implements the co-programmed European Partnership Photonics.

Call - Digital and emerging technologies for competitiveness and fit for the Green Deal

HORIZON-CL4-2024-DIGITAL-EMERGING-01-CNECT

Conditions for the Call

Indicative budget(s)[264]

Topics	Type of Action	Budgets (EUR million)	Expected EU contribution per project (EUR million)[265]	Indicative number of projects expected to be funded
		2024		
Opening: 15 Nov 2023				

[264] The Director-General responsible for the call may decide to open the call up to one month prior to or after the envisaged date(s) of opening.
The Director-General responsible may delay the deadline(s) by up to two months.
All deadlines are at 17.00.00 Brussels local time.
The budget amounts are subject to the availability of the appropriations provided for in the general budget of the Union for years 2023 and 2024.

[265] Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.

Deadline(s): 19 Mar 2024				
HORIZON-CL4-2024-DIGITAL-EMERGING-01-21	RIA	20.00	4.00 to 6.00	4
HORIZON-CL4-2024-DIGITAL-EMERGING-01-23	CSA	2.00	Around 2.00	1
HORIZON-CL4-2024-DIGITAL-EMERGING-01-31	RIA	33.00	Around 33.00	1
HORIZON-CL4-2024-DIGITAL-EMERGING-01-34	CSA	3.00	Around 3.00	1
HORIZON-CL4-2024-DIGITAL-EMERGING-01-42	RIA	15.00	Around 15.00	1
HORIZON-CL4-2024-DIGITAL-EMERGING-01-45	IA	15.00	4.00 to 5.00	3
Overall indicative budget		88.00		

General conditions relating to this call	
Admissibility conditions	The conditions are described in General Annex A.
Eligibility conditions	The conditions are described in General Annex B.
Financial and operational capacity and exclusion	The criteria are described in General Annex C.
Award criteria	The criteria are described in General Annex D.
Documents	The documents are described in General Annex E.
Procedure	The procedure is described in General Annex F.
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G.

Open Source for Cloud/Edge and Software Engineering Fundamentals to support Digital Autonomy

Proposals are invited against the following topic(s):

HORIZON-CL4-2024-DIGITAL-EMERGING-01-21: Open Source for Cloud/Edge to support European Digital Autonomy (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of between EUR 4.00 and 6.00 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 20.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Technology Readiness Level	Activities are expected to start at TRL 4 and achieve TRL 6 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to both of the following outcomes:

- Prototypes of cloud and edge servers demonstrated in relevant centralised and distributed environments and allowing full computing infrastructure deployments based on European processor technology, thereby establishing a full Open Computing Architecture stack, which supports emerging processing architectures (e.g. RISC-V).
- Standards and best practices consolidating the European Open Computing Architecture, as well as its interfaces to current industry standards.

Scope: Proposals should facilitate the emergence of a full **European Open Cloud and Edge Computing Architecture** by

- Developing open source alternatives to enable the physical use of emerging processors in cloud and edge server systems. Such modules include basic input/output systems, pre-boot execution environments, power-on authentication, etc., supporting heterogeneous processor architectures, and

- Demonstrating actual cloud and edge systems in real life or emulated computing environments exploiting the benefits of an extended open source stack (socket to application) on emerging processor architectures (e.g. RISC-V).

Research should interface with relevant existing standards and contribute to standardisation where appropriate.

Proposals should include a clear business case and exploitation strategy.

Proposals are expected to develop synergies and relate to activities and outcomes of the KDT/Chips and the EuroHPC Joint Undertakings, the European Processor Initiative and the European RISC-V working group. They should complement the development of European HW and related low-level software as done under the KDT and EuroHPC JUs, to make these exploitable for cloud and edge servers and make use of previous developments under Horizon Europe.

HORIZON-CL4-2024-DIGITAL-EMERGING-01-23: Public recognition scheme for Open Source (CSA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 2.00 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 2.00 million.
Type of Action	Coordination and Support Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: If projects use satellite-based earth observation, positioning, navigation and/or related timing data and services, beneficiaries must make use of Copernicus and/or Galileo/EGNOS (other data and services may additionally be used).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the

	Research and Training Programme of the European Atomic Energy Community (2021-2025). [266].

Expected Outcome: Projects are expected to contribute to both of the following outcomes:

- Establishment of a system of European annual awards that acts as a spotlight stirring up contributions to Open Source Software and Hardware projects.
- Increased interest for the contribution to, integration of and exploitation of Open Source assets

Scope: The action should first develop a scheme including a list of fields related to Open Source. An indicative but non-exhaustive nor obligatory list of topics could include deep contributions to kernel code, brilliant utilization of open source in companies' new developments. The action should elaborate an adequate process to

- scrutinize different fields of action relevant to open source,
- select appropriate candidates for being recognised,
- implement adequate award ceremonies.

Proposals should involve appropriate expertise in Social Sciences and Humanities (SSH), in particular in sociology and human behaviour, to achieve a wider interest in the efficient exploitation of available open source assets.

Proposals submitted under this topic should include an exploitation strategy, as outlined in the introduction to this Destination, which allows recurrent awards.

Additionally, a strategy for skills development should be presented, associating social partners when relevant.

Projects should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes.

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

Graphene and 2D materials: Europe in the lead

Proposals are invited against the following topic(s):

[266] This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf

HORIZON-CL4-2024-DIGITAL-EMERGING-01-31: Pilot line(s) for 2D materials-based devices (RIA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 33.00 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 33.00 million.
Type of Action	Research and Innovation Actions
Technology Readiness Level	Activities are expected to start at TRL 3-4 and achieve TRL 5-6 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Broadly accessible pilot line(s) fostering the creation of electronic and photonic devices and systems (co-)integrating two-Dimensional Materials (2DM).
- Significant progress towards the adoption of the 2DM in the silicon and semi-conductor arena by allowing the production of new (co-)integrated devices and systems in a quality controlled way.

Scope: Proposals shall continue the efforts started in the 2D experimental Pilot Line of the Graphene Flagship and build on the IP developed therein, to establish a 2DM pilot line(s), where European companies, research centres and academic institutions, can produce on a pilot scale novel electronic and/or photonic devices and systems integrating 2DM.

Proposals should focus on the (co-)integration of 2DM with established technologies such as CMOS[267] integration and heterogeneous integration.

Proposal should include supply of standard semiconductor technologies such as CMOS, ASICs[268], planarized waveguides already adapted/optimized for 2DM co-integration.

Proposals should specify targeted added value(s) against current technologies of the integrated devices and systems. Proposals should consider the following TRLs: for Electronics applications starting TRL 3 with ending TRL 5 and for photonics applications starting TRL 3-4 and ending TRL 5-6.

Multidisciplinary research and innovation activities should address all of the following:

267 Complementary metal–oxide–semiconductor (CMOS)
268 Application-specific integrated circuit (ASIC)

- Building the toolkit and design modules necessary for creating prototype devices and systems, characterise and assess their performance and their ability to cover the device requirements of the targeted applications.
- Process characterisation and monitoring to control and guarantee quality of relevant device parameters and to allow yield predictions of the integrated devices.
- Adaptation of standard semiconductor technologies including passivation schemes, strategies to align devices over different technologies, modules to contact the 2D devices with the periphery, optimized planarization strategies and packaging services.
- Reliability and packaging requirements;
- Implementing multiple wafer runs or other offering to best cover business opportunities;
- Defining a sustainable model of functioning beyond the project lifetime and include activities preparing for the later transfer of the pilot line to an industrial production environment; examples of such activities include addressing relevant cost issues and market perspectives, potential business partners, etc.

Proposals submitted under this topic should include a business case and exploitation strategy, as outlined in the introduction to this Destination.

Research should build on existing standards or contribute to standardisation. Interoperability for data sharing should be addressed.

Proposals should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes and platforms. In particular projects are expected to develop synergies and relate to activities and outcomes of the projects selected under the other topics of 'Graphene and 2D materials: Europe in the lead' and where relevant of the KDT JU.

Proposals should also cover the contribution to the governance and overall coordination of the Graphene Flagship initiative.

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

HORIZON-CL4-2024-DIGITAL-EMERGING-01-34: Synergy with national and regional initiatives in Europe (CSA)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 3.00 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 3.00 million.
Type of Action	Coordination and Support Actions
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Eligible costs will take the form of a lump sum as defined in the Decision of 7 July 2021 authorising the use of lump sum contributions under the Horizon Europe Programme – the Framework Programme for Research and Innovation (2021-2027) – and in actions under the Research and Training Programme of the European Atomic Energy Community (2021-2025). [269].

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Well-coordinated European, national and regional initiatives in the field of graphene and two-dimensional materials (2DM);
- Further development of a strong European innovation ecosystem in 2DM-based technologies.

Scope: Proposals should support the coordination between relevant national and regional public authorities funding research and innovation in 2DM-based technologies. This coordination should allow them to work synergistically with the goal to strengthen and complement the EU funded activities in the domain.

Coordination and support activities should address all of the following:

- Active networking of relevant initiatives and R&I communities.
- Active follow-up of the projects funded under FLAG-ERA[270].
- Maintaining an inventory of funding and scientific landscapes in the domain of 2D materials in Europe, for both basic and applied research.
- Analysing gaps and overlaps and contributing to topics that could be included in national/regional research agendas in the field.
- Supporting the national and regional actors to organise joint calls for proposals between their respective programmes and initiatives for supporting in Europe the further development of a strong innovation ecosystem in Graphene.

269 This decision is available on the Funding and Tenders Portal, in the reference documents section for Horizon Europe, under 'Simplified costs decisions' or through this link: https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ls-decision_he_en.pdf

270 https://www.flagera.eu

Projects should build on or seek collaboration with existing projects and develop synergies with other relevant European, national or regional initiatives, funding programmes and platforms.

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

Flagship on Quantum Technologies: a Paradigm Shift

Proposals are invited against the following topic(s):

HORIZON-CL4-2024-DIGITAL-EMERGING-01-42: Stimulating transnational research and development of next generation quantum technologies, including basic theories and components (Cascading grant with FSTP)

Specific conditions	
Expected EU contribution per project	The Commission estimates that an EU contribution of around EUR 15.00 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 15.00 million.
Type of Action	Research and Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, and security, participation in this topic is limited to legal entities established in Member States, associated countries, OECD and Mercosur countries. Proposals including legal entities which are not established in these countries will be ineligible. This decision has been taken on the grounds that, in the area of research covered by this topic, EU open strategic autonomy is particularly at stake. It is important to avoid a situation of technological dependency on a non-EU source, in a global context that requires the EU to take action to build on its strengths, and to carefully assess and address any strategic weaknesses, vulnerabilities and high-risk dependencies which put at risk the attainment of its ambitions. For the duly justified and exceptional reasons listed in the paragraph above, in order to guarantee the protection of the strategic interests of the Union and its Member States, entities established in an eligible country listed above, but which are directly or indirectly controlled by a non-eligible country or by a non-eligible country entity, may not

	participate in the action unless it can be demonstrated, by means of guarantees provided by their eligible country of establishment, that their participation to the action would not negatively impact the Union's strategic, assets, interests, autonomy, or security[271].
Technology Readiness Level	Activities are expected to start at TRL 1-4 and achieve TRL up to 6 by the end of the project – see General Annex B.
Procedure	The procedure is described in General Annex F. The following exceptions apply: If funding for projects funded under topic is coming from more than one EU programme, this action is an EU Synergy grant[272] and the following conditions will apply: In all cases, this is provided that no double funding occurs, the cumulative financing does not exceed the total eligible costs of the action, and the support from the different Union programmes is calculated on a pro-rata basis in accordance with the documents setting out the conditions for support (Art. 15.4 of the Horizon Europe Regulation and Art. 63.9 of the Regulation on Common Provisions of the Structural Funds).
Legal and financial set-up of the Grant Agreements	The rules are described in General Annex G. The following exceptions apply: Beneficiaries may provide financial support to third parties. The support to third parties can only be provided in the form of grants. The maximum amount to be granted to each third party is EUR 700.000 in order to allow third parties to achieve closer coordination and greater

271 The guarantees shall in particular substantiate that, for the purpose of the action, measures are in place to ensure that:
a) control over the applicant legal entity is not exercised in a manner that retrains or restricts its ability to carry out the action and to deliver results, that imposes restrictions concerning its infrastructure, facilities, assets, resources, intellectual property or know-how needed for the purpose of the action, or that undermines its capabilities and standards necessary to carry out the action;
b) access by a non-eligible country or by a non-eligible country entity to sensitive information relating to the action is prevented; and the employees or other persons involved in the action have a national security clearance issued by an eligible country, where appropriate;
c) ownership of the intellectual property arising from, and the results of, the action remain within the recipient during and after completion of the action, are not subject to control or restrictions by non-eligible countries or non-eligible country entity, and are not exported outside the eligible countries, nor is access to them from outside the eligible countries granted, without the approval of the eligible country in which the legal entity is established.

272 Calls could be EU Synergies calls, meaning that projects that have been awarded a grant under the call could have the possibility to also receive funding under other EU programmes, including relevant shared management funds. In this context, applicants should consider and actively seek synergies with, and where appropriate possibilities for further funding from, other R&I-relevant EU, national or regional programmes (such as ERDF, ESF+, JTF, EMFF, EAFRD, Innovation Fund and InvestEU), where appropriate, as well as private funds or financial instruments.

	mobilisation and pooling of resources between regional, national and EU research programmes for realising the research goals of the Quantum Flagship in the area of quantum technologies. Proposals are expected to use financial support to third parties (FSTP) to achieve closer coordination and greater mobilisation and pooling of resources between regional, national and EU research programmes for realising the research goals of the Flagship in the area of quantum technologies. A minimum 85% of the EU funding requested by the proposal should be allocated to the purpose of financial support to third parties, selected through joint calls with the participating national funding agencies. Third parties will be funded through projects of around EUR 2.5 million per project. The EU will contribute with up to 33% of the national contribution to the projects.

Expected Outcome: Projects are expected to contribute to the following outcomes:

- Support to transnational projects in quantum technologies, fostering synergy between European, national and regional initiatives and promoting broader partnerships between the European stakeholders in quantum technologies.

Scope: Proposals should support the networking and coordination of national activities in support of the Quantum Flagship by implementing calls for proposals resulting primarily in grants to third parties in this area, in accordance with the provisions of the General Annexes. i) the gaps in the Strategic Research Agenda, not covered by the Flagship activities; (ii) support transnational efforts in guaranteeing availability of critical technologies, materials and resources essential for a competitive development of next generation quantum technologies and central to strategic supply chains for an autonomous and technologically sovereign pan-European quantum ecosystem; (iii) support early-stage involvement of industry in transnational R&D agendas to next generation quantum technologies, emphasizing high inclusion and participation of SME and start-ups in realizing an innovative and agile pan-European quantum ecosystem.

Proposals should make provisions to actively participate in the common activities of the Quantum Flagship and in particular contribute to the activities of the existing Quantum Coordination and Support Action.

HORIZON-CL4-2024-DIGITAL-EMERGING-01-45: Quantum sensing and metrology for market uptake (IA)

Specific conditions	
Expected EU	The Commission estimates that an EU contribution of between EUR 4.00

contribution per project	and 5.00 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 15.00 million.
Type of Action	Innovation Actions
Eligibility conditions	The conditions are described in General Annex B. The following exceptions apply: In order to achieve the expected outcomes, and safeguard the Union's strategic assets, interests, autonomy, and security, it is important to avoid a situation of technological dependency on a non-EU source, in a global context that requires the EU to take action to build on its strengths, and to carefully assess and address any strategic weaknesses, vulnerabilities and high-risk dependencies which put at risk the attainment of its ambitions. For this reason, participation is limited to legal entities established in Member States, Iceland and Norway and the following additional associated country: Israel[273]. For the duly justified and exceptional reasons listed in the paragraph above, in order to guarantee the protection of the strategic interests of the Union and its Member States, entities established in an eligible country listed above, but which are directly or indirectly controlled by a non-eligible country or by a non-eligible country entity, may not participate in the action unless it can be demonstrated, by means of guarantees provided by their eligible country of establishment, that their participation to the action would not negatively impact the Union's strategic, assets, interests, autonomy, or security [274]

[273] Legal entities established in Israel are eligible to participate in this action on the basis that (i) Israel is an associated country (and continues to be on the date of the opening of this topic for submission); and (ii) Israel meets specific conditions. Prior to the adoption of this Work Programme, questionnaires were sent to non-EEA associated countries and countries in the process of association in order to assess their eligibility to participate.

[274] The guarantees shall in particular substantiate that, for the purpose of the action, measures are in place to ensure that:
a) control over the applicant legal entity is not exercised in a manner that retrains or restricts its ability to carry out the action and to deliver results, that imposes restrictions concerning its infrastructure, facilities, assets, resources, intellectual property or know-how needed for the purpose of the action, or that undermines its capabilities and standards necessary to carry out the action;
b) access by a non-eligible country or by a non-eligible country entity to sensitive information relating to the action is prevented; and the employees or other persons involved in the action have a national security clearance issued by an eligible country, where appropriate;
c) ownership of the intellectual property arising from, and the results of, the action remain within the recipient during and after completion of the action, are not subject to control or restrictions by non-eligible countries or non-eligible country entity, and are not exported outside the eligible countries, nor is access to them from outside the eligible countries granted, without the approval of the eligible country in which the legal entity is established.

Technology Readiness Level	Activities are expected to start at TRL 4-5 and achieve TRL 6-7 by the end of the project – see General Annex B.

Expected Outcome: Projects are expected to contribute to mature quantum sensing technologies and devices (TRL 6-7) in different application sectors, with the goal of establishing a reliable, efficient supply chain including first standardisation and calibration efforts for rapid market uptake.

Scope: Proposals should address the development of mature quantum sensing technologies and single or network-operating devices that have the potential to find a broad range of new applications including but not limited to transportation, precise localisation and timing, navigation, metrology, health, biology, security, telecommunications, Radio Frequency sensing and processing, imaging and recognition, radars energy, electronics industry, construction, mining, prospection, aerospace, materials, automotive, energy transformation etc...

Proposals should demonstrate advanced prototypes of such sensing technologies that provide an unprecedented level of precision and stability, making new types of sensing, imaging and analysis possible. For rapid market uptake, they should target miniaturised, integrated, transportable quantum sensors and provide first plans for their further industrialisation and target customers through enhanced cost efficiency and user operability at higher TRL.

In order to achieve the above, proposals should include relevant actors from the whole value chain (from materials to devices and to system integration aspects). They may also include, wherever relevant: (i), activities and actors from metrology institutes that would provide measurement methods and/or standards, including for the development of quality assurance methods and for standardisation of the targeted quantum sensing technologies; (ii) strategies such as validation and benchmarking to other technologies in order to clearly identify quantum advantage and hereby assist successful and competitive market placement; (iii) where necessary, to achieve the projects objectives, activities could also address more fundamental research issues; (iv) the cooperation with complementary projects launched specifically in the area pilot capabilities ("FPA for open testing and experimentation and for pilot production capabilities for quantum technologies" HORIZON-CL4-2021-DIGITALEMERGING-02-22), to lower the threshold for industry via the transfer infrastructure provided by application labs, testbeds as well as fabrication and pilot line facilities being addressed under the synergetic FPA suggested above.

Finally, proposals should also cover: (any additional support they may receive from relevant national or regional programmes and initiatives, including the contribution to the governance and overall coordination of the Quantum Technologies Flagship initiative.. They should also contribute to spreading excellence across Europe, for example, through the involvement of Widening Countries.

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