Pillar 1 – Research Infrastructures

Empowering Europe through world-class and accessible Research and Technology Infrastructures

Research Infrastructures (RIs), including the European Open Science Cloud, and Technology Infrastructures (TIs)[1] are crucial enablers of research and innovation. Europe needs an effective and integrated landscape of RIs and TIs that helps covering the continuum of needs from fundamental knowledge creation to technology deployment and support the implementation of Open Science policies.

European Framework Programmes have made a significant contribution towards the more efficient and effective use of national Research Infrastructures (RIs) and have developed with the European Strategy Forum on Research Infrastructures (ESFRI) a coherent and strategy-led approach to policy making on pan-European research infrastructures. The work with ESFRI resulted in the development of plans for 55 European Research Infrastructures, of which 37 have already been implemented, across all fields of science, mobilising close to €20 billion in investments[2]. Many of these research infrastructures (21) have been established as European Research Infrastructure Consortia (ERIC) – a legal form enshrined in EU law and the only EU regulation in the ERA framework – that enables joint funding from the Member States and associated countries and secures their commitment to continuing support.

Europe has a rich landscape of Research Infrastructures. For the future, smart investments will be required to drive the development of new research infrastructures towards filling knowledge gaps and supporting emerging needs. At the same time, efforts to optimise and consolidate the existing capacities, avoiding fragmentation and duplications, will provide ERA with a more effective and well-functioning Research Infrastructure landscape.

This is well reflected in the recently published ESFRI White Paper, which put new emphasis on a consolidated European research infrastructure ecosystem underpinning the ERA, which builds on the existing facilities at European and national level, and integrates new Research Infrastructures in strategic areas to address EU's broad policy priorities. RIs, as also highlighted by the ESFRI White Paper, have the potential to contribute to local and regional socio-economic development by triggering the creation and playing a central role in knowledge innovation hubs. In this context, closely interacting with local businesses and industry, they support regional research priorities and the implementation of the Smart

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[1] Research Infrastructures (RIs) are facilities that provide resources and services for the research communities to conduct research and foster innovation in their fields. This definition includes the associated human resources, and it covers major equipment or sets of instruments; knowledge-related facilities such as collections, archives or scientific data infrastructures; computing systems, communication networks, and any other infrastructure, of a unique nature and open to external users, essential to achieve excellence in research and innovation. Where relevant, they may be used beyond research, for example for education or public services and they may be 'single sited', 'virtual' or 'distributed'.

Technology Infrastructures (TIs) are facilities, equipment, capabilities and support services required to develop, test and upscale technology to advance from validation in a laboratory up to higher TRLs prior to competitive market entry. They can have public, semi-public or private status.

2 See http://roadmap2018.esfri.eu/.

Specialization Strategies (S3).

In the RI landscape, the European Open Science Cloud (EOSC) offers an ecosystem of standards, technologies and services, along with rules of engagement, which will enable and enhance seamless access to and reliable re-use of research outputs, i.e. data, software and other digital objects, included those generated or collected by other research infrastructures, supporting the whole research data life cycle (with infrastructures digital services and data) from discovery and mining to analysis, storage and management. High-speed connectivity (GÉANT) underpins the development of EOSC and provides fast, trusted and reliable connectivity for researchers in Europe and beyond. Delivering EOSC as a trusted virtual environment supporting Open Science and data and service-driven research and the activities in this area will be designed in cooperation with MSs and stakeholder in the framework of the proposed EOSC European partnership. This will allow Europe to seize data-intensive science opportunities and enable breakthroughs at the crossroads of different disciplines.

EU Framework Programmes have so far fostered the opening at EU level of RIs to trans-national users, enabling all researchers in Europe to have access to the best RIs they need for their research. These efforts have radically transformed the availability of state-of-the-art facilities for researchers, reinforcing Europe's strong research performance and its ability to react rapidly, for example in providing reference materials worldwide for the coronavirus outbreak. Up to now, this approach has been mainly science driven.

As European RIs have the potential to enhance society's long term and consistent problem-solving capacity, new efforts are now needed to ensure the provision of customised and results-oriented RI services and resources to accelerate the transition towards a green and digital future and to support an effective and responsive health system as well as evidence-based policy-making. In this regard, Research Infrastructures can substantially contribute to the objectives of the Pillar II clusters and the Horizon Europe (HE) missions.

In order to continue to address the global environmental, social and economic challenges, the renewed ERA requires an explicit contribution of research infrastructures themselves to Europe's wider policy objectives, thus maximizing the contribution of science to the needs of the society and increasing Europe's competitiveness.

To cope with new challenges and ensure leadership of Europe in frontier research, RIs need to be at the forefront of technological developments. This will require investments for the development of off-the-shelves cutting-edge scientific instrumentation, software and methods. These developments, often done in cooperation with industry, will advance the industrial technological level in Europe and lead to breakthrough technological and societal innovation.

Training for RI users will underpin all the activities implemented under the RI work programme, thus contributing to the education of the next generation of researchers.

A well-functioning RIs landscape and its continuous evolution and upgrade will make the ERA attractive for researchers from all over the world.

Policy objectives and key targets for 2021-2024

The policy context - the political priorities of the Commission, together with the overall

objectives of the Horizon Europe programme to tackle global challenges through research and innovation - provides a strong baseline to develop a target-oriented strategy for the coming programming period.

Destination #1: A well-functioning European Research Infrastructure landscape

Policy context: ERA Communication; ESFRI White Paper 2020

Objective: Develop a European strategy for Research and Technology Infrastructures and create a coherent, reactive and attractive RI landscape, by reducing the fragmentation at national and regional level, ensuring coordination of efforts and alignment of priorities among MSs, federating and connecting RIs to the EOSC, and strengthening regional and national R&I ecosystems. Enhance the role of RIs for international cooperation and science diplomacy.

Main impact: Enable disruptive research and breakthrough innovation through cutting-edge, interconnected and sustainable Research Infrastructures, which make the ERA attractive to researchers from all over the world and fill knowledge gaps among countries and regions. Underpin the R&I effort enabling systemic changes needed for a truly transformative societal and economic recovery and a strengthened resilience of critical sectors, as outlined in the Recovery Plan. Increase the capacity of Europe to respond, in cooperation with international players, to emerging challenges at global level.

Current status/Challenges:

Over recent years, the European Commission and Member States have been closely collaborating with the European Strategy Forum on Research Infrastructures (ESFRI) to develop an integrated and efficient ecosystem of RIs, which encompasses single-sited facilities, distributed EU facilities, networks of national facilities and which serves researchers and engineers in all S&T fields. To facilitate integration and pooling of resources for the development of new capacities, a legal instrument has also been developed at European level, the European Research Infrastructure Consortium (ERIC) that provides favourable conditions for the establishment and operation of large EU infrastructures among several MSs and ACs as well as third countries. While Member States remain central in the development and financing public research infrastructures, the Union plays a catalysing and leveraging role in this field.

The challenges for the near future are to define effective, sound and coherent RI and TI strategies in Europe, in close cooperation with ESFRI, as well as to consolidate and optimise the European Research Infrastructure landscape and enhance its capacity to support frontier research and address the emerging and new scientific and societal objectives associated with the transition towards a sustainable and resilient Europe.

While TIs-related activities are supported in Pillar II of HE, there is a need to develop an integrated vision that links the RI and TI concepts taking into account their respective nature and the communities they serve.

Achievements sought / Key targets:

- Implement the ESFRI Roadmap 2021, aligning and leveraging MS investments for the establishment, operation and long-term sustainability of European Research Infrastructures. A strategic approach based on ESFRI roadmap will allow ensuring responsible agreements among MS/ACs and formal engagements for establishing new RIs and final plans for their implementation.

- Develop new concepts for the next generation of unique European Research Infrastructures, single/multi sited, distributed or virtual, that none or few Member States might individually be able to afford or implement. A mixed approach will allow, on one side, to target gaps in areas linked to the key political priorities, notably health and green and digital transition, and, on the other side, to address emerging scientific needs for new discoveries and major knowledge advancements in fundamental science;

- RI merging, reorientation and decommissioning, or development of service level agreements between RIs to consolidate and enhance coherence and cost-effectiveness of the European RI landscape. A targeted approach, based on scientific cases and governance options, will be developed with ESFRI, along the whole life-cycle of RI development.

- Enhance the presence of European Research Infrastructures on the international scene through effective participation in international fora for RIs policy (e.g.: EU-CELAC activities; GSO; Russia flagship) as well as through the development of interoperability, harmonisation and exchange of best practices to address challenges of global dimension, such as climate change, migration and pandemics;

- Strong European presence and lead in global development of FAIR research outputs (e.g. data and open science methodologies protocols, software, code, standards and guidelines) by active participation in global discussions and fora, such as RDA;

- Increased visibility of RIs through outreach activities and citizen engagement; Set up the strategy and framework conditions for a European ecosystem of Technology Infrastructures.

Destination #2: Enabling an operational, open and FAIR EOSC ecosystem

Policy context: Open Science, Europe fit for the digital age; European Data strategy, EOSC, ERA Communication

Objective: Develop the European Open Science Cloud (EOSC) as an operational enabling ecosystem for FAIR research data commons, based on key horizontal core functions and service layers accessible to researchers across disciplines and countries, leading to a "Web of FAIR Data and Services" for Science.

Main impact:

- Transforming the way researchers as well as the public and private sectors share and

exploit research outputs (data, publications, protocols, methodologies, software, code, etc.) within and across research disciplines leading to better quality and more productive research results

- Facilitating scientific multi-disciplinary cooperation, leading to discoveries and solutions in key areas such as environment and health

- Seamless access to increasing volumes of research data (that is as FAIR as possible) and other research outputs stimulating the development and uptake of a wide range of new innovative and value-added services from public and commercial providers

- Improving trust in science through increased openness and quality of scientific research in Europe, supported by more meaningful monitoring and better reproducibility and validation of research results, and by improving pathways for the communication of science to the public

Current status/Challenges:

The EOSC ecosystem is under development through a series of projects supported in Horizon 2020 and an interim EOSC governance structure preparing the next stage of EOSC development after 2020. These EU-funded projects have contributed to the creation of a pan-European access mechanism; coordination of national activities for EOSC onboarding; connection of European Research Infrastructures (ESFRI and other world-class RIs); initial setting and operationalisation of the FAIR principles and a FAIR-compliant certification scheme for research data infrastructures; EOSC portal providing access to a range of services, guidelines and training; and the development and provision of a number of research enabling and value-added services (both public and commercial). The EOSC cluster projects should continue fostering connectivity and interoperability of ESFRIs within EOSC and the forthcoming Strategic and Innovation Agenda (SRIA) of the EOSC Partnership. From 2021, the envisaged open and inclusive partnership will help ensuring directionality (common vision and objectives) and additionality (complementary commitments and contributions) of all the stakeholders involved.

Achievements sought / Key targets:

- Initial deployment of a Web of FAIR data (e.g. persistent identifiers, metadata, semantic artefacts and ontology schemes, frameworks for machine-actionable and interoperable data, ensuring privacy, security and building on existing standards).

- Deployment of an EOSC platform based on federated core, enabling access to a wide ecosystem of data and services (e.g. authentication and authorization, support to the full cycle of scientific workflows, collaboration environments for users, access to AI and HPC services and computing and storage, customised environments for resource and service providers, R&I enabling value-added services etc.).

- Development and prototyping of innovative, agile and customisable services that complement and scale up the service offering of the federated EOSC platform to serve a wide variety of users, including links and RI contributions to Common European Data Spaces and key scientific "data lakes" outside of the EOSC ecosystem.

- The EOSC ecosystem underpins the reward of open science practices and data stewardship that improve trust, quality and productivity in science and provides substantially improved access to data, tools and services produced by major European and national research infrastructures through the EOSC environment.

- Vast numbers of diverse research communities are linked to the first large pan-European federated ecosystem of FAIR data and services, which is further linked to the Common European Data Spaces.

- The EOSC ecosystem should interact with global partners and initiatives for interoperability and alignment of infrastructures, wherever feasible.

Destination #3: RI services to support health research, accelerate the green and digital transformation, and advance frontier knowledge

Policy context: Europe fit for the digital age, European Data Strategy, European Green Deal, Economy that works for people; ESFRI White Paper; Industrial strategy, ERA Communication, EOSC; Recovery plan

Objective: Provide efficient and customised research and innovation services to drive and enable the transition toward a sustainable Europe, a prosperous economy and an inclusive society. RI services (e.g. access to unique scientific tools, samples provision, processing and analysis, data services) will be directed to support an effective and responsive health and care system and to accelerate the transition towards a green and digital future. A possible action would aim at scaling up and better integrating RI services to advance the understanding of biodiversity loss, climate change and its societal, economic and environmental impacts. At the same time, Research Infrastructures services will also continue enabling the advancement of frontier knowledge. In this context, further development and access to services of the EBRAINS federated infrastructure of the Human Brain Project for neuroscience, health and brain inspired technologies will be supported.

Main Impact: Enhance and increase society's long-term and consistent problem-solving capacity in areas linked to health, and the green and digital transition, including a better understanding of socio-economic and overall cultural implications, through the provision of innovative, customised and efficient RI services.

Current status/Challenges: Research communities across Europe are equipped with state-of-the-art services and resources for their scientific activities. The provision of services at EU level was so far mainly organised per types of infrastructures or disciplines. The complexity and urgency of the socio-economic and environmental transition that Europe is facing, requires interdisciplinary approaches and a challenge-driven provision of customised services able to accelerate the pace of the research cycle and the delivery of solutions. RIs are key players in the generation of fundamental knowledge and drivers of scientific excellence in Europe.

Achievements sought /Key targets:
- Seamless and challenge-driven provision of RI services will strengthen European

capacity to solve specific research challenges in key priority areas. Examples include, but are not limited to, customisation of and access to light sources services for the development of innovative energy storage solutions and innovative materials; access to brain research services empowering the neuroscience community, clinicians and industry researchers; pipelines of RI services to support research life-cycle on cancer, infectious diseases, personalized medicine; provision of socio-economic data for policy-making. The ad-hoc training for users will prepare the new generations of researchers to properly exploit leading-edge RIs, and will provide them with appropriate skills for data stewardship.

- Seamless provision of RI services to enable frontier research and boost the production of new scientific knowledge in fundamental science, e.g. in astronomy, physics, earth sciences, biology, etc.

Destination #4: Next generation of scientific instruments, tools and methods and advanced digital solutions

Policy context: Europe fit for the digital age, European Green Deal; ERA Communication; European Industrial Strategy, EOSC, Technological sovereignty

Objective: Develop ground-breaking RI technologies, including scientific instruments, tools, methods, and advanced digital solutions, to enable new discoveries and keep Europe's RIs at the highest level of excellence in science, while paving the way to innovative solutions to societal challenges and new industrial applications, products and services. New instruments and tools (such as advanced sensors, imaging devices, light/neutron source detectors) and advanced digital solutions (e.g. digital twins, brain modelling and simulation) for RI upgrade, will enable solutions to be found even for the most demanding – and sometimes not yet even conceivable – scientific and societal challenges.

Main Impact: Ensure that Europe remains globally competitive and at the forefront of technological excellence in an extremely fast-moving environment through investments into the development, in cooperation with industrial actors where appropriate, of forward-looking technical instruments and tools for European RIs. The development, deployment and availability of the next generation of RI technologies will play a central role in supporting, with advanced instrumentation, latest modelling and prediction technologies, the transition towards a sustainable and healthy society, and will enhance the competitiveness of European industry.

Current status/Challenges:

Scientific communities cannot adequately respond to current research challenges without having access to state-of-the-art scientific instruments and tools. Their constant adaptation, upgrading and innovation, as the underlying technologies develop at a very rapid pace, is critical for providing the optimal conditions for scientific advancements and discoveries in Europe. The current COVID-19 emergency highlights the relevance of developing and making widely available state-of-the-art science and technological capabilities and facilities for the European researchers to fight global threats.

Achievements sought / Key targets:

- Deliver innovative scientific instrumentation, tools and methods to maintain the state-of-art of European RI, thus serving a wide community of users and/or new areas of research. Upgraded technologies will enhance the potential of RIs to contribute to new science discovery and to addressing EU policy objectives, for example the green deal.

- Building interoperable digital solutions and digital twins for interdisciplinary scientific communities that would permit to model and simulate ultra-complex phenomena and advance scientific discovery as well as delivering socio-economically beneficial technical and software solutions based on such digital twins and interoperable combinations thereof.

Destination #5: Network connectivity - enabler for collaboration without boundaries

Policy context: Europe fit for the digital age, Economy that works for people, Connectivity strategy, digital sovereignty

Objective: Provide faster, resilient and secure connectivity for supporting scientists with close to real-time applications that enable evidence-based decision-making in society and world-wide effective collaboration of virtual communities

Main impact:

- Putting Europe at the forefront of global Research and Education: creating the necessary conditions to attract data and talent by offering borderless collaboration services, ensuring very high-bandwidth, reliable and secure end to end cross-border connectivity among users, European and International Research Infrastructures (RIs), computing facilities & data repositories, and paving the way for widespread access to common European Data Spaces.

- Achieve connectivity globally and foster Europe's international cooperation policy objectives via enhanced connectivity of the R&E networks between Europe and different parts of the world

Current status/Challenges:

Gigabit connectivity across the EU: By the end of H2020 programme, GÉANT will have completed the most important backbone network upgrade in its history, building a resilient meshed network with a lifespan over 15 years and reaching with 100Gbps to almost every country in the EU. This will constitute the foundation for the next generation cross-border connectivity system, which must cater for an ever-increasing traffic demand and non-discriminatory access, meaning access to every ERA country in multiples of 100Gbps and backbone capacities reaching the order of Tbps.

Research connectivity with other countries of the world: GÉANT provides international connectivity that enables access with many other regions of the world (Africa, the

Mediterranean region, Middle East and Central Asia). Direct links are also provided to North America and the Asia Pacific region via the Advanced North Atlantic (ANA) agreement & Asiapacific-Europe Ring (AER) Collaboration while long-term approaches have been established for the EU-Brazil cable (25 years) and the link to Singapore (15 years.)

Achievements sought / Key targets:

- Increase the capacity of the core backbone network in multiples of 100 Gbps and continue supporting the operations of cross-border core network services and the development of new ones to cater for the new needs of Europe's innovation and research centres. Examples of such new services include multi-domain configurations, software defined networking (SDN), network function virtualisation (NFV), etc.

- Provide advanced network services which facilitate seamless exchange of FAIR data, enable access and interoperability to the different European Data Spaces and provide technical solutions that maximise the usability of available resources and talent (e.g. fostering collaboration and sharing of data between researchers, industry and SMEs).

- Deploy and customize European AAI (Authentication and Authorisation Infrastructures) to be fully compatible and interoperable with the eIDAS Regulation.

- Achieve long-term contracts and agreements for international connectivity that cater for the upcoming traffic growth, and provide a resilient network architecture in agreement with major Research and Education Networks world-wide.

- Upgrade existing connections, acquire new capacity (or spectrum) from existing links and participate in the construction of new strategic links like for example the prospective Arctic Link or the renewal of approaching end-of-life links to North America.