ERIC Forum Implementation Project

Draft policy report 2

Work Package 6 - Deliverable 6.5

Deliverable no	6.5
Deliverable Title	Draft policy report 2
Contractual delivery month	March 2021
Responsible Partner	ECRIN-ERIC
Author(s)	WP6 Forward Looking Task Force

Executive summary

The objective of WP6 ***Role of ERICs in European science policy and research strategy*** consists of organizing regular ERIC FORUM seminar discussions where national, European and international science policymakers, funding agencies, ERIC governance bodies, research institutions and representatives of the research communities meet to jointly address science policy issues raised by the development of science and technology and by the impact of ERICs on the European research ecosystem, and to develop productive synergies.

Within this framework, WP6 deliverables ensure the production of periodic science policy reports on jointly identified topics of critical interest for ERICS which shall be validated during the ERIC FORUM seminars and disseminated by the Forward Looking Task Force (FLTF). The objective of these policy reports is to better inform the relevant European policy and decision-making bodies of topics critical to the ERICS, helping to expand their impact and their contribution to an innovative and sustainable European Research Area. Upon finalization, the reports are disseminated by the FLTF and all Forum members.

The selection process of the priorities for the ERIC FORUM seminars and policy reports proposed by the FLTF is described in described in Deliverable D6.1, 6.2 and 6.3 (see Reference).

The first topic selected, “Funding models for access to ERIC multinational / transnational services”, was presented during the ERIC FORUM seminar in M21 (September 2020).

ERIC Forum has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N. 823798

The second policy report topic *Socio-economic impact (SEI) of ERICs* was selected in M19 (July 2020) following the consensual participative procedure described Deliverable D6.1. However, following a parallel WP4-WP6 initiative to synergize actions regarding SEI-related deliverables, after WP6-wide consultation and vote, all WP6 members and the EF coordination agreed to align the delivery date of the policy brief *Socio-economic impact of ERICs* with that of Task 4.3 Report on SEI ERIC Framework [1]. An amendment on the timeline for this deliverable is pending.

Hence the selection process of the second topic for the WP6 second policy brief was relaunched. The topic *Scaling-up research projects through ERICs: impact of big science on the research ecosystem* was selected in November 2020 (M23) by the WP6 FLTF members with the delivery date M30 (June 2021). The updated delivery timelines of both these policy reports 2 and 3 (D 6.5 to 6.9) were agreed to be communicated to the EU Project Officer during the TCs with WP6 and the coordinator to take into consideration the processes and time required for deliberation, voting and timeline alignment.

This preliminary draft of the second ERIC Forum policy report on *Scaling-up research projects through ERICs: impact of big science on the research ecosystem*, presents the collaborative work of the ERIC FORUM on a key topic of common interest. Throughout this policy brief, selected case studies underscore the achievements of RIs to provide urgent or framework solutions. The case studies illustrate the rich and diverse RI landscape, activities and scope. In total 24 case studies, domain specific or cross-domain, showcase the breadth and depth of the innovative technologies addressing today and tomorrow's key societal challenges. The challenges and hurdles to advancement at different levels are presented with actionable recommendations to forge the way forward so that RIs can serve their purpose as the "backbone of ERA" within a sustainable framework.

This draft will continue to evolve, as the dedicated WP6 Task Force Writing Team continues editing and drafting. The report will be finalized in collaboration with key stakeholders either during a seminar organized with all the key stakeholders in collaboration with an ERIC/ESFRI/RI event to present the policy brief, or due to timeline constraints via an email consultation to ensure that the policy brief benefits from the relevant expert insight outside of the ERIC FORUM project and is not produced in a silo. The same approach shall be taken for the final policy report during 2022 (Y4).

[1] *The mentioned timelines are recorded in minutes of WP6 meetings dating from December 2020 as well as the presentations during the ERIC FORUM Management Meetings 2020-2021 available on the EF sharepoint.*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Copyright notice

Document log

Issue	Date (yyyy-mm-dd)	Comment	Author/partner
1.0	2021-11-24		Golbahar Pahlavan ECRIN-ERIC
2.0	2021-12-06		Golbahar Pahlavan ECRIN-ERIC

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Table of Contents

1.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Background

Clarify the background behind the problem the deliverable is aiming to solve.

As defined in Task 6.1, annual science policy reports shall be drafted and disseminated by a "Forward Looking Task Force" (FLTF) within WP6. The topics to be covered in the annual policy reports are chosen collectively by the members of the FLTF. The policy reports inform the preparation of the ERIC FORUM seminars, and are further discussed during the seminars (Task 6.13 - 15) with all the ERIC FORUM representatives and relevant stakeholders in view of their finalization and dissemination by the FLTF through selected European and international channels.

This document reports the delivery of the draft second policy brief on *Scaling-up research projects through ERICs: impact of big science on the research ecosystem* based on previously identified priorities and methodology developed for the previous ERIC-FORUM Policy Reports (please see below and References).

Approaches (Methods)

Describe the steps that have been undertaken for the deliverable.

The Forward Looking Task Force is composed of representatives from 22 partner ERICs and associated organizations 2, who work in a broad array of research domains. All ERIC FORUM beneficiaries have been invited to join the FLTF on a voluntary basis, through an email consultation. Partners having agreed to join the FLTF then select their institutional representatives.

In order to identify the priorities for the ERIC FORUM seminars, a preliminary list of relevant policy topics was proposed and discussed at the kick-off meeting. Additional topics were added during the meeting following consultations and discussions. A shortlist was then created by the Task Leader with all the topics that could be of relevance to all partners. The shortlist was sent to the FLTF and votes were collected on each topic through email discussions and a teleconference.

The first topic selected for the ERIC FORUM Policy Brief 1 was: "Funding models for access to ERIC multinational / transnational services". This report was presented at the ERIC FORUM on-line Seminar which took place virtually on September 14-15th, 2020 (M21).

The topics for the second and third policy reports were selected following the same methodology. The previously selected priorities (please see below) were submitted to vote following the same agreed and validated procedures with 1 vote per participating ERIC:

1. Scaling-up research projects through ERICs: impact of big science on the research ecosystem
2. Capacity building: ERICs unlocking scientific potential throughout European countries and regions
3. ERICs and international cooperation
4. Socio-economic impact of ERICs
5. Scientific evaluation of the ERICs
6. Integration of ERIC development into pan-European e-Infrastructures, particularly in the new European Open Science Cloud-EOSC

Following the selection of the topic for the second policy brief in November 2020 (please see section If delivery is late, enter here the explanation) regular TCs were organized with the WP6 FLTF and the dedicated volunteer-based Writing Team from December 2020- November 2021. (please see appendix) to collectively draft the policy brief. The full schedule of TCs is provided in the table below:

[2] ECRIN, EATRIS, LIFEWATCH, EUROBIOIMAGING, BBMRI, CLARIN, JIVE, EU ARGO, EMSO, EMBL, EU-OPENSCREEN, INFRAFRONTIER, SHARE, CESSDA, CERIC, EMBRC, INSTRUCT, DARIAH, EMPHASIS, ECCSEL, ESSS, ICOS

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

WP4/WP6	WP6	Coordination
11/09/2020		
30/09/2020		
29/10/2020 WP4/WP6	16/10/2020	23/10/2020 ExBo
	3/11/2020 LIFEWATCH	
	18/12/2020 TC1 PB2	
	22/1/2021 TC2 PB2	26-27/1/2021 Annual Meeting
1/3/2021 TC1 D4.3/D4.4	4/3/2021 TC3 PB2	
31/3/2021 TC2 D4.3/D4.4	15/4/2021 TC4 PB2	
3/5/2021 TC3 D4.3/D4.4	21/5/2021 TC5 PB2	7/5/2021 PMT
27/5/2021 TC4 D4.3/D4.4	25/6/2021 TC6 PB2	
	08/10/2021 WT Leads	
	11/10/2021	
	18/10/2021 WT	
18/11/2021 TC5 D4.3/D4.4		

Results

DRAFT POLICY BRIEF 2: SCALING-UP RESEARCH PROJECTS THROUGH ERICS: IMPACT OF BIG SCIENCE ON THE RESEARCH ECOSYSTEM

EXECUTIVE SUMMARY

Since their inception, Research Infrastructures (RIs) have been designed as the technological cornerstone of the European Research Area (ERA), to nurture scientific excellence for the advancement and application of science to

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

societal challenges, ranging from our place in the Universe, to climate change and emerging virus threats, by providing cutting edge skills, tools and services. European RIs, whether virtual, single-site or distributed, contribute through their network of users, partners and collaborators at local, regional and international levels to science-based activities and communities, building competitive ecosystems and knowledge-based economies.

The COVID-19 pandemic starkly revealed, once again, that research challenges do not recognise national borders. There is an urgent need for cooperation at the organisational level to mobilise resources efficiently and effectively to tackle global challenges.

Scaling up means investing in programmes that have proven successful and building on these to better address present and future research priorities. Research infrastructures are uniquely positioned to respond to demands that require emergency mobilization or cutting-edge resources, thereby contributing to both the scaling-up of services and their fast uptake as well as providing solutions for prevention and mitigation. A key feature of European Research Infrastructures is their strong connection with key national and regional stakeholders, as well as other RIs, which facilitates interdisciplinary collaborations and sharing of good practices and valuable policies. In scaling up, many of the processes already in place are ready for expansion and adaptation, saving time and resources to get up to speed.

The interplay between the different actors in the quadruple helix: local and regional government support and funding; academic research, industry partnerships and civil society involvement is critical for effective scaling-up and sustainability.

This second ERIC FORUM policy brief showcases the pivotal role of RIs in the European R,D&I ecosystem at the interface of technology users and providers, as well as the scientific and societal impact of the big investments made in European science through the RIs including direct and indirect spill over effects considering their diverse modes of tackling societal challenges.

Throughout this policy brief selected case studies illustrate the achievements of RIs to provide urgent or framework solutions. The case studies illustrate the rich and diverse RI landscape, activities and scope. In total 24 case studies, domain specific or cross-domain, showcase the breadth and depth of the innovative technologies addressing today and tomorrow's key challenges. Each case study is preceded by a short presentation of the RI. The challenges and hurdles to advancement at different levels are presented with actionable recommendations to forge the way forward so that RIs can serve their purpose as the "backbone of ERA" within a sustainable framework.

The recommendations to optimise the research ecosystem supporting Big Science are as follows:

1. The benefit and added value of the ERIC should be manifest when engaging in projects or activities in which individual partners have interest, in order to avoid conflicts of interest.

2. The role of pan-European research infrastructures as Big Science instruments among the public research communities and the industry should be highlighted.

3. Large-scale interdisciplinary collaboration should be promoted across RIs and scientific communities mobilizing collective intelligence to prioritize research questions and the design of research protocols.

4. The operational and legislative frameworks for data standards, sharing, reuse and analysis should be strengthened.

5. Authorship rules, evaluation criteria and career development policies should be developed to promote the participation of research and infrastructure staff in large-scale, highly collaborative projects.

6. The participation of third-countries in ERICs, despite not endorsing the ERIC regulations, should be encouraged by other different forms, such as participation regulated by a MoU, which could set a favorable context for the collaboration.

7. Member State support for RIs should be promoted in projects funded by national programs in Member States, supporting the national node and increasing the quality and impact of the proposed activities. The national rules for

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

eligibility should be adapted to allow acceptance of ERICs (which, for example, would be beneficiary only if applying to the calls in coordination with the national RI).
8. ERICs in any Member State, independently of the details of the hosting arrangements, must be clearly recognized as a distinct, international, established institution with its own legal entity as per the ERICs regulations, different from the national RI. The EC must be vigilant to ensure that all the partners respect the ERIC entities.
9. Funding mechanisms should be adapted to unfold the full potential of ERICs and to meet the needs of Big Science projects in terms of volume of funding, of multinational and cross-border availability, and of prioritization of large scale projects that will benefit from ERIC infrastructure support.
10. The EC must maintain its role and support ERICs beyond the preparation phase, through instruments such as the INFRADEV contracts, to support and facilitate international collaboration.
11. ERICs are valuable to the industry, increase the visibility of the collaboration by creating an "ERIC label" that the industry can exploit for reputation, and an "industry board" to maintain the link.
12. Global expansion or partnerships with ERICs should be promoted to foster collaborations in global research projects to tackle shared challenges.
13. Science-based policy-making should be supported by strengthening the dialogue between ERICs and policy-makers.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

BACKGROUND

A synthesis of historical accounts of European scientific cooperation on Big Science and RIs demonstrates their role in unlocking scientific potential in European countries and regions. The global political history connects the two concepts of Big Science and Research Infrastructures; indeed, RIs in Europe follow the evolution of Big Science from the Cold War. Although RIs differ with the latter given the emphasis on public goods rather than military or national security objectives[3]*. Nevertheless, science and technology have had a critical role in shaping geopolitics; during the race to develop new energy sources, transport systems, military technologies, as several large-scale programs were launched by industrialised countries. Big Science was conceived as a powerful means to guarantee scientific coordination, collaboration, and integration between fragmented scientific initiatives and to align European countries' intergovernmental and collaborative interests on a large scale. Since then, a shift of focus towards innovation in a systemic view has occurred in Europe, transforming the landscape.*

Nowadays, science is a more active player in societal issues and researchers are asked to develop more effective solutions for a sustainable future. The societal challenge, from now on, is the balance between handling economic contraction while creating new opportunities considering environmental safeguard. "Recovery today and resiliency tomorrow" is more than just hype; it is a call for action. The pandemic effects can be a catalysing factor, but a practical global multiplayer cooperation must overcome fragmentation-related issues. A paradigm shift is required, together with stronger societal cohesion and collaboration in almost all sectors, and policies for accelerating the transition to a knowledge-based economy. Science is one of the fittest means to address significant challenges, including increasing environmental risks, food insecurity, pandemics and other health-related risks. And it is becoming increasingly multidisciplinary for a more comprehensive approach to complex problems. It is a fact that many research projects are operated (and even funded) at a national or regional level.

The cross-cutting nature of Sustainable Development[4] *demands a holistic view; the social, economic and natural sciences are asked to contribute to systemic approaches supporting transformative socioeconomic- financial-ecological systems. Increasing research responsibility for societal challenges opens a new scenario for ERICs towards an integrated and cross-domain strategy. Development of pathways for the ecological transition asks for the planning and diffusion of new technological, economic, social, and innovation models built upon new knowledge in energy production, storage and distribution, natural resource exploitation and environmental monitoring, logistic, resources supply and treatment and health.*

[3] *Investing in Science, Massimo Florio, 2019 MIT Press*
[4] *https://www.un.org/sustainabledevelopment/*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

INTRODUCTION

Big Science represents a fundamental change in the way research is designed, funded and conducted. Although its implementation and impact vary across scientific disciplines, Big Science relies on two major enablers, the large Research Infrastructures acting as instruments for high-throughput data generation, and the Big Data technology able to exploit and analyse these large datasets. Progressively spreading from physics to the environment, health, human and social sciences, Big Science has resulted in major scientific achievements with substantial societal impact.

According to the EU definition in Article 2(1) of the Regulation (EC 2021/695)[5] of the Horizon Europe Framework Programme, Research Infrastructure "means facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields". However, according to the ESFRI roadmap, European Research Infrastructures represent more than merely large scientific instruments, as they are multinational by essence. By requiring a minimum of three member countries, the ERIC legal status adds a political dimension[6], as ERICs are also science policy and strategic instruments (ESFRI Roadmaps[7]) for multinational cooperation, unlocking the latent scientific potential, fostering integration of research and innovation in Europe and supporting the development of the European Research Area. This results in a distinction between national or local facilities, and pan-European Research Infrastructures (although a significant number of distributed infrastructures build on the federation of national facilities).

Whether single-sited or distributed, size matters for Big Data generation by the Research Infrastructures in a highly competitive global scientific environment. For Research Infrastructures, high-throughput data generation requires expertise on leading-edge technology and methodologies, and appropriate procedures to ensure data quality, reliability and reproducibility. On the other hand, Big Data technology allows optimal use and analyses of this data through data storage facilities, high performance computing, modelling, artificial intelligence, data sharing and reuse. Building on Research Infrastructures and on Big Data technology, Big Science has resulted in emerging research methods and approaches, for instance the data-driven research in parallel to hypothesis-driven research. Beyond data-driven research, a significant number of new results and achievements would have been impossible without the qualitative and quantitative support of the Research Infrastructures in generating high-throughput quality data (see for instance the use cases described in the following chapters of this policy brief). In addition, these instruments make it possible to address new scientific questions and societal challenges that could not be solved otherwise. Cooperation between Research Infrastructures acts as a powerful enabler for transdisciplinary research, one of the most promising and innovative areas of frontier science, while infrastructures in closely related areas may cooperate through alliances[8]. Research Infrastructures collaborate as disciplinary clusters, and cross -cluster collaboration allows both cross-fertilization and support to complex projects requiring multiple technological and methodological expertise.

The prominent role of European Research Infrastructures in Big Science development raises a number of challenges, in particular with regards to the optimal use of available resources in terms of human capital, funding of the Research Infrastructure and their supported projects[9] as well as competitiveness and sustainability. As research resources are limited, a critical question for the scientists, the operators of research infrastructures, and the science policymakers lies in the balance, for each individual research project, between the breadth and the granularity of the collected data.

---

[5] *REGULATION (EU) 2021/695 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 April 2021 establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, and repealing Regulations (EU) No 1290/2013 and (EU) No 1291/2013 https://eur-lex.europa.eu/eli/reg/2021/695/oj*

[6] *Big Science and research infrastructures in Europe, Cramer KC and Hallonsten O eds, Edward Elgar Publishing 2020.*

[7] *https://www.esfri.eu/esfri-roadmap*

[8] *EU Alliance of Medical Research Infrastructures, www.eu-amri.org*

[9] *ERIC FORUM Policy Brief « Funding Models for Access to ERIC Multinational/ Transnational Services" https://www.eric-forum.eu/wp-content/uploads/2020/09/ERIC-Forum_Policy-Brief.pdf*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Big Science and the use of Research Infrastructures also impact the competition vs. cooperation balance among scientific communities: large-scale projects, requiring significant resources, foster a collective approach to the prioritization, design, planning, conduct, analysis, publication and exploitation of the experiment. Other components of the research ecosystem also have to be considered, including a harmonised regulatory framework, data interoperability, and last but not least, the availability and level of sustainable multinational funding schemes.

ERICs: CROSS-DISCIPLINARY KNOWLEDGE AND INNOVATION HUBS

The launch of ERIC organizational form signed an unprecedented commitment by the EU in the integration of the research and innovation area in response to scientific and societal challenges by creating an appropriate legal framework to facilitate their establishment and operation at the level of the Community [10]. At Member State level, as well as at intergovernmental fora such as the Global Science Forum (GSF) and G7, European policies rely on RIs to boost the international competitiveness of the European Common Market, backed by science, technology and innovation for sustainable growth. The European Strategy Forum on Research Infrastructures (ESFRI), as an important point of reference for RI funding through national and EU schemes, contributes to the alignment of RI decision-making by integrating smart specialization strategies with national RI roadmap development. The ESFRI Monitoring System and Roadmaps provide the framework for the evaluation and implementation of RIs with the objective to strengthen the scientific integration of Europe through a coherent and strategy-led approach to policy-making and by facilitating multilateral initiatives for the better use and development of research infrastructures at EU and international levels.

ERICs, by definition and nature, cover the full cycle of knowledge production to technological and innovative potential in their scientific domains. They are driven by a broader mission in addition to providing targeted solutions within co-designed and cooperative framework which through scaling up can respond to an overarching common goal beyond the single missions or even disciplines and knowledge domains to contribute collectively to achieving the SDGs as illustrated by the analysis conducted by the ERIC Forum on the contribution of the ERICs to the Horizon Europe Missions [11].

Whether virtual, single-site or distributed through multiple nodes, RIs develop and provide, through their expertise and equipment, cutting edge technology and services to their users. The technical requirements of RI instruments to explore the frontiers of science far exceed existing commercial tools, positioning RIs on the forefront of technological developments. Collaboration between RIs and their users and partners across networks avoids fragmentation and duplication while contributing to cross-fertilization and interdisciplinary research. The unique combination of scientific excellence, cutting edge technology and interdisciplinary research partnerships anchored within a loco-regional ecosystem provides the RIs with the capacity to respond rapidly to major global challenges such as the COVID-19 pandemic.

The recent COVID-19 pandemic revealed the strengths and gaps in global research and development. It underscored the pivotal role of robust reactive research infrastructure networks capable of bringing together multidisciplinary expertise and technology to provide real-time solutions. This powerful resource nurtured through national and European funding schemes such as the Framework Programmes is one of the cornerstones of European preparedness and response by providing multiple perspectives for generating unique and creative solutions

In the following section selected case studies underscore the achievements of RIs either alone or in collaboration as integrated innovation hubs providing urgent real-time or long-term framework solutions across scientific domains. The case studies are preceded by the presentation of the respective RI(s).

[10] *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R0723*

[11] *ERIC FORUM position paper: The ERIC Community and the Horizon Europe Mission Areas: bit.ly/30GHBiV*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Instruct-ERIC https://instruct-eric.eu/ is the European structural biology research infrastructure, bringing together many of Europe's highest quality instruments, scientific and technical expertise in methods and approaches for the structural characterisation of biological molecules in their cellular context. Instruct supports integration of different structural biology technologies including cutting-edge technologies and its infrastructure advances as new technologies and methods emerge that expand the structural resolution of biological processes.
EU-OPENSCREEN ERIC https://www.eu-openscreen.eu/ is a non-profit research infrastructure which operates on a global scale to offer access to academic high-throughput screening facilities and medicinal chemistry groups in member countries.

Case Study 1 Boosting the development of COVID-19 antivirals
Instruct partnered with EU-Openscreen to screen chemical libraries for potential anti-COVD19 therapeutic agents using new high-throughput structural screening methods. The method contributed to a world-wide initiative https://covid.postera.ai/covidMoonshot, a crowdsourced initiative to accelerate the development of a COVID antiviral. Submitted drug designs and experimental data were analysed using public supercomputing power to inspire and design new chemical structures that could optimise target hits identified through the screen.

Case Study 2 Portal for high quality COVID-19 reagents
Instruct developed a new reagent portal to answer the rapid need for high quality COVID19 reagents which was used to deliver high quality standardised reagents for COVID19 research during 2020 when there was a crucial need for reference materials to accelerate the research. The portal was built on the foundations of the Instruct ARIA system, an infrastructure management system which was purpose built as a flexible and adaptable platform which is in use by several ESFRIs and national infrastructure facilities.

The European Clinical Research Infrastructure Network ECRIN-ERIC www.ecrin.org was designed as a 'Big Science' instrument with the mission to support multinational clinical trials, thus allowing to recruit more patients and to faster deliver robust, statistically powered and generalizable evidence. ECRIN federates and coordinates national networks of clinical trial units providing operational support to multinational trial management. Recent developments in trial methodology, and data generation and management offer new opportunities for scaling up Europe's clinical research potential.

Case Study 3 Accelerating clinical research on COVID-19 through platform trials
In response to the COVID19 outbreak, **ECRIN** contributed to the development, coordination and implementation of pan-European multi-arm adaptive 'platform' trials, sharing a single master protocol and the control arm to simultaneously test multiple treatment options for repurposing marketed drugs, to develop innovative treatments, or to test vaccines. The new design helps ECRIN to support platform trials in other medical fields whenever multiple treatments have to be evaluated and compared in a given disease condition.

The pivotal role played by RIs at the interface of users and developers leads to the provision of unique cross-disciplinary skillsets, deep knowledge repositories as well as the opportunity for developing quality standards and sharing of good practices to optimize resources and research capacities.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Euro-BioImaging ERIC www.eurobioimaging.eu, is the pan-European Research Infrastructure for biological and biomedical imaging, that offers open access to cutting-edge biological and biomedical imaging technologies, training and data services. It enables advanced research in areas such as cancer, neurodegenerative or infectious diseases - expediting the understanding of the biological processes underlying health and disease and supporting drug discovery. Euro-BioImaging also drives scientific progress in areas such as plant and marine biology - providing key insights in the behavior of ecosystems under stress or in changing conditions, such as the ones associated with climate change.

Case Study 4 Access to Life Science RIs interdisciplinary services

In the course of the CORBEL project (H2020 GA N. 654248), **Euro-BioImaging** co-led the first launch and set-up of Open Calls for multidisciplinary research projects, through which researchers could access a combination of the services and technologies offered by different ESFRI Life Science RIs. This paved the way to the establishment of a number of service pipelines across diverse RIs, enabling cutting-edge interdisciplinary research of broad impact in a streamlined fashion. The projects supported through CORBEL with access to multiple RIs highlighted the multiplicative effect of joining service offers in different fields, particularly for the implementation of truly cutting-edge research and has been replicated in several other scenarios since.

Case Study 5 Centralized scientific image data archive

In close collaboration with **Euro-BioImaging** the centralised image data services via the BioImage Archive at EMBL facilitates access to scientific image datasets linked to a publication or to public studies from basic up to preclinical research, enabling the implementation of FAIR principles for key research image data. The BioImage Archive can be used for consultation purposes and to develop new tools, for reuse and re-analysis of existing data sets. The establishment of a centralised repository represents a breakthrough for the scientific community and offers the opportunity to connect image data to other data modalities, allowing cross-domain research and synergies, such as connecting image data and sequence data in the COVID-19 Data portal.

BBMRI-ERIC https://www.bbmri-eric.eu is a European research infrastructure for biobanking that brings together all the main players from the biobanking field – researchers, biobankers, industry, and patients – to boost biomedical research.

Case Study 6 Linking researchers to samples across the globe

BBMRI-ERIC Negotiator is a Service that provides an efficient communication platform for biobankers and researchers requesting samples and/or data. It substantially simplifies the communication steps that are necessary to obtain information on the availability of relevant samples/data, particularly if the researchers need to communicate with multiple candidate biobanks. The Negotiator 2.0 is connected to the already established BBMRI-ERIC Directory, the biggest biobanking catalogue on the globe.

Case Study 7 Facilitating the secondary use of clinical trial patient level data and metadata

Clinical trial data produces large datasets for patient stratification and promotes reproducibility (re-analyses) and evidence synthesis (meta-analyses) that helps to optimize the scientific output of clinical research. **ECRIN** implements the **clinical research metadata repository** crmdr.org and a patient-level clinical trial data repository allowing GDPR-compliant data sharing for COVID19 trials. Data generation and quality control is a major cost driver in clinical trials and data re-use from electronic health records and databases or from cohorts and registries, can be transformative.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

ECRIN is working to lower the cost and facilitate data collection in trials, which is expected to dramatically increase the amount of evidence generated and ultimately benefit the health systems.

CESSDA-ERIC https://www.cessda.eu/ is the Consortium of Social Science Data Archives which provides a full-scale sustainable research infrastructure enabling effective solutions to the major challenges facing society today and improving skills in the social sciences. CESSDA is a leader in social sciences and humanities data discovery across Europe.

Case Study 8 Bringing together trusted Social Science Data Repositories

CESSDA brings together trusted social science data repositories, aiming at full European coverage, with tools and services available to data producers and data re-users. CESSDA provides access to social science data and metadata through the CESSDA Data Catalogue, promoting FAIR principles and interoperability with the European Open Science Cloud (EOSC). The CESSDA DC™ has over 35 000 datasets on various social sciences topics, searchable and documented in numerous European languages with rich metadata that facilitates cross-disciplinary research, all from a single access point. The DC™ ensures that quality data is more accessible and usable by a wide range of users, academic, non-academic, policy makers, not just in Europe but all over the world.

CESSDA and its national Service Providers CESSDA have embraced the many challenges of the global COVID-19 pandemic and its significant societal and health-related impacts. All COVID-19-related metadata is harvested to the CESSDA Data Catalogue as they become available to CESSDA Service Providers.

The European Social Survey ESS ERIC www.europeansocialsurvey.org is a research infrastructure in the social sciences and humanities domain , established as an ERIC in 2013. The ESS carries out academic cross national, cross sectional surveys of social attitudes and behaviors every two years in up to 37 participating countries since 2002. The results of nearly half a million hour-long interviews are freely available for non-commercial use and available from its Archive. To date the number of registered data users with the ESS ERIC Archive is over 180 and the analysis of data usage indicates that there are nearly 5,500 academic publications using ESS data.

Case Study 9 Joining forces to monitor urban greenhouse gas emissions

ESS and Integrated Carbon Observation System ICOS ERIC – as part of a new H2020 award ESS ERIC is supporting ICOS ERIC in their new H2020 project. The project - Pilot Application in Urban Landscapes - towards integrated city observatories for greenhouse gases (PAUL) - will provide a concept for monitoring greenhouse gas observations.

Coordinated by ICOS - Integrated Carbon Observation System, it will bring together and evaluate the most innovative measurement approaches of greenhouse gas emissions in urban areas and will develop useful tools and services for cities to support their local climate action plans. To test the feasibility of different modelling approaches in different areas, three cities of different size have been selected as pilots: Paris (large), Munich (medium) and Zürich (small). As part of PAUL, the ESS will develop the methodology for an online questionnaire that will collect survey data measuring public opinion regarding climate change policies at the city level. The ESS will then plan and operate a four-wave survey with a gross sample of 2,500 respondents in two of the pilot cities: Paris and Munich. This is the first time ESS ERIC has cooperated with an ERIC outside of the SSH domain on a substantive topic.

ESS ERIC is expected to sign an MoU with the other Social Science and humanities Research Infrastructures (SHARE ERIC, CLARIN ERIC, CESSDA ERIC AND DARIAH ERIC) to continue the collaboration after the end of the SSHOC cluster project related to the building of the EOSC. This will facilitate future cooperation.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

EPOS www.epos-eu.org, the European Plate Observing System, is a multidisciplinary, distributed European Research Infrastructure that enables the integrated use of data, data products, and research facilities from the solid Earth science community in Europe. EPOS ERIC is based in Rome and joined by fourteen European countries. The EPOS mission is to establish and underpin a sustainable and long-term access to solid Earth science data and services integrating diverse European Research Infrastructures under a common federated framework. EPOS is composed of a variety of Earth Science stakeholders that are together work for the integration of European Earth Science National Research Infrastructures into a single interoperable platform. EPOS will develop implementation plans and use new e-science opportunities to monitor and understand the dynamic and complex solid Earth system.

Case Study 10 Sharing multidisciplinary solid Earth sciences data

The research community included in EPOS represents over 140 research organisations, as well as about 250 national RIs in Europe, covering ten different disciplines in solid Earth sciences. Since 2007, the EPOS research community has designed a federated framework that takes into account technical, governance, legal, and financial aspects for the establishment of a comprehensive and sustainable multidisciplinary research platform for Earth sciences in Europe. EPOS is currently in the transition from the implementation phase to the operational phase. Two major achievements to date are, on the one hand, the organisation of domain-specific research communities as Thematic Core Services, with a common approach to data integration and governance; and the development of the e-infrastructure (Integrated Core Services, ICS-C), whereby (FAIR) data across multiple domains can be explored and accessed to by users. The establishment of a centralised platform for integrated data is unique in the solid Earth sciences domain, and represents an opportunity for broadening the range of users of solid Earth sciences in Europe.

EMPHASIS https://emphasis.plant-phenotyping.eu/ is the European Research Infrastructure of plant phenotyping, providing services supporting sustainable intensification of crop production to ensure amount and quality of biomass for nutrition and industry at changing climate conditions. EMPHASIS addresses sustainable and improved crop production in different, current and future, agro-climatic scenarios, helping to translate high-throughput genotypic analysis of crop variants to high-throughput and high-resolution phenotyping in order to identify high-yield crop varieties for defined environmental conditions.

Case Study 11 Directory for European plant phenotype

EMPHASIS aims to create access to phenotyping data by building and integrating compatible, consistent information systems. Towards that end, EMPHASIS helps with installing information system in local infrastructures, to be interconnected via a pan-European application to make them interoperable and re-usable. It collaborates with ELIXIR (and further RIs in the context of EOSC-Life) to enable data integration across communities.

ERICs: DRIVERS OF EUROPEAN RESEARCH INTEGRATION, EXCELLENCE AND COMPETITIVENESS

RIs are important for their contribution both to the Excellence of European science and innovation as well as for the integration of the European Research Area given their multinational scope. They act as catalysts for economic growth by promoting innovation, supplying high-quality employment and implementing trans-national cooperation. They provide a backbone for innovation by involving not only scientific and technological communities of practice, but also decision makers and the civil society. At the regional level, local industries and stakeholders benefit from the proximity and privileged access to research infrastructures which boost local innovation and confer competitive advantage. In

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

addition to the technological collaborations with public and private sectors and the related knowledge transfer, in many cases the construction of the infrastructure facilities itself provides the opportunity for local industry to work on the technological development of the facility. RIs thus generate a significant local socio-economic impact across a range of constituencies and, as such, provide an incentive for regions to attract RIs in their territory, or to invest in them financially.

Solution-oriented research builds on fundamental upstream research carried out in academia, and thus has to be embedded in a multi-domain research landscape and broader funding structures. Such cross-domain collaboration, beyond distinct disciplines and between science and policy, impacting society, is possible in concrete terms through ERICs. Each RI contributes to fostering and supporting excellence in science, emerging technologies and providing the growth of the innovation-driven economy, encouraging solution-oriented research in its disciplines and knowledge domains. RIs can affect intersectoral collaboration, drawing paths to support regional knowledge-based growth, strengthen synergies, and, ideally, monitor them. The contribution of the RIs in increasing territorial development and sustainability is feasible starting from the optimisation and valorisation of its nodes. The bottom-up approach implies strengthening the nodes (mainly within distributed RIs) and the scientific and technological network at Member State levels, attracting new research and funding partners and triggering spill over effects within their ecosystem.

The multidisciplinary collaborations of ERICs, within their multinational networks, with academia, industry, and the civil society contribute to increased awareness regarding scientific and societal challenges as well as the provision of tools and methods for tackling them. Novel knowledge, skills, tools and expertise are developed or sharpened to address bottlenecks in research and development with spill over effects at different levels including capacity building.

Case study 12: ERICs as catalysts for strengthening the European Research Area

European Social Survey and European Values Study https://europeanvaluesstudy.eu/.

The European Values Study (EVS) is a large-scale, cross-national, repeated cross-sectional survey research programme on basic human values. It provides insights into the ideas, beliefs, preferences, attitudes, values and opinions of citizens all over Europe. The European Values Study covers a wide range of human values. The main topics concern family, work, environment, perceptions of life, politics and society, religion and morality, national identity. As part of the ESS-SUSTAIN-2 H2020 grant ESS ERIC is exploring a future partnership with the EVS which may lead to an EVS module in the ESS in future as a special rotating module as well as well as cooperation in other areas such as training. Work on developing such a module is underway as are data comparisons between the ESS and the EVS data time series.

1. Building leading-edge capacity through training, access to cutting-edge services, and mobility

Training

Research infrastructures are, in addition to their complex and expensive equipment, repositories of knowledge and expertise. In ERICs, the added value of regional and/or international cooperation in the context of service to users, offers great opportunities to foster knowledge transfer and human capacity building.

There are several ways in which this is achieved:

- Hands-on training of users that visit the ERIC hub, any of its nodes or its associated service facilities
- Training events (schools, workshops, courses, webinars, etc.) coordinated by the ERIC, and in synergy with the needs of users of other ERICs,
- Staff exchange, in short or long visits to the ERIC hub or among the nodes,

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

- Facilitating the development and dissemination of high-quality manuals and online tools, available through the ERIC website.

The above-mentioned activities are organised by the ERIC, often with the help from European Transnational Access (TNA) programs that act as a catalyser, providing "seed money" and motivation. The European contracts also set the grounds for stronger compromise among partners. Thematic RI clusters such as the European environmental Research Infrastructures (ENVRI) and European Life Science Research Infrastructures (LSRI) also provide powerful collaborative platforms for training, sharing knowledge, tools and best practice and to ensure the interoperability and optimal use of resources.

Access to cutting-edge facilities

ERICs include the support to the users of their facilities in their mission. The researchers cannot not be expected to be experts in each technique or use of the instrumentation required to produce their science. This support has to be guaranteed by adequate resources. It is demonstrated that expert support to the users of research infrastructures increases the chances that they will consider including it in their studies. Since ERICs offer access through open calls, in which the proposals are evaluated and selected only by considering the scientific quality and technical feasibility, the ERIC must be ready to provide extensive support in the preparation, execution, and analysis of the research program, including physical visits to the ERIC sites when necessary. On the other hand, successful applicants to ERIC access programs should get recognition and support from their own institutions and national programs, providing complementary resources to those offered by the ERIC.

ERICs can facilitate cross-disciplinary research by the arrangement of procedures that allow the continuation of approved studies also in other facilities. The users then get advice and are guided through that process. This can include, but is not limited to, access to online resources such as archives or databases.

Training events coordinated by the ERIC optimize the preparation efforts for a maximum impact. Introductory schools to the ERIC field of expertise, organised at the ERIC premises (hub or nodes) but also online, allow to increase the awareness of potential users and also the networking among them and with the experts, and their engagement into the community. An important added value is that the course material prepared can be translated to the local language by the ERIC nodes, increasing the accessibility by removing the language barrier.

A good example is the "Iniciativa VLBI IberoAmericana" (IVIA), which uses the know-how of JIVE ERIC and partners to create training possibilities in Spanish that can be easily accessed by the growing communities of radio astronomers in Latin America. Another example is the training pilot service provided by EMPHASIS, which targets researchers and technicians from academia and industry, including early-career researchers, PhD students, hardware and software engineers, technology developers and end-users (e.g. farmers and agronomists) by providing individualised training measures, but also by coordinating training activities together with neighbouring research infrastructures.

More focused workshops or webinars are also organised by ERICs, and kept available in a repository for future access after the event.

Mobility

Staff exchange, in short or long visits to the ERIC hub or any of the nodes, has the obvious advantage of ensuring hands-on work with the experts. It also promotes networking and engagement. When the visit is consequence of user support, as mentioned above, it adds the valuable information that the user can provide to the ERIC staff regarding their needs and expectations, which serves to improve the support but also the services that the ERIC provides.

Last, but not least, communication is essential to guarantee that human capacity building reaches all potential users, taking special care of diversity in a very proactive way.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Case Study 13 Global BioImaging training

The European RI Euro-BioImaging ERIC https://www.eurobioimaging.eu/ is one of the founding members of the international network of imaging infrastructures and communities called Global BioImaging (www.globalbioimaging.org). Global BioImaging today comprises 11 partners representing national or regional imaging infrastructures and communities in Europe, Japan, Australia, Mexico, South Africa, India, Singapore, Canada as well as North and Latin America, all bound by an umbrella MoU.

23 Global BioImaging (www.globalbioimaging.org) is an international network of imaging infrastructures and communities, which today counts 11 international partners representing the communities in their

Country or region: Euro-BioImaging ERIC, Japan's Advanced Bioimaging Support, Microscopy Australia, Australia's National Imaging Facility, Mexico's National Laboratory for Advanced Microscopy, South Africa

BioImaging, India BioImaging Consortium, Singapore Microscopy Infrastructure Network, BioImaging North America, Canada BioImaging and Latin America Bioimaging.

Global BioImaging (GBI) was initiated in December 2015 by an H2020 international cooperation grant, awarded to Euro-BioImaging. The grant allowed the nascent infrastructure to strengthen its fledgling bonds with partners in Argentina, Australia, India, Japan, South Africa and the USA and build a sustainable framework for international cooperation. The international relationships deepened over time, with more and more partners coming on board. The project evolved into an actual international network of research infrastructures and communities, which today enjoys generous support by the Chan Zuckerberg Initiative, which finances most of its activities.

In practice, Global BioImaging organizes:

- Annual international workshops called "Exchange of Experience" (https://globalbioimaging.org/exchange-of-experience) to learn from leaders around the globe in infrastructure operation and management, research policies, technology trends and the latest developments in bioimaging worldwide.
- Focused meetings and working groups to discuss specific subjects of interest to the international bioimaging community, build international collaborations and publish international recommendations.
- A comprehensive training program, composed of webinars, online and in person courses as well as an online resource to support the professional development of managerial and technical staff working in bioimaging Research Infrastructures and facilities (https://globalbioimaging.org/international-training-courses).
- A staff exchange program (called Job Shadowing) to allow imaging facility staff to learn from leading international peers on-the-job, by visiting selected facilities and shadow expert personnel in their daily work (https://globalbioimaging.org/international-job-shadowing-program).

The Global BioImaging coordination, hosted by the intergovernmental organization EMBL, also plays a key advocacy role for bioimaging worldwide: it supports the GBI partners to **build a strong case** "at home" (i.e. towards local funders) that imaging technologies are key in the advancement of life sciences and therefore require adequate infrastructure investments.

2. Knowledge transfer spillovers: collaborations with universities, SMEs, civil society

Industry collaborates with RIs as service developer and user providing employment opportunities which may lead to developing new capacities. Furthermore, collaboration with RIs gives industrial and civil society partners access to cutting edge technologies for solving challenges they face at local and/or global level.

The European Spallation Source ESS-ERIC https://europeanspallationsource.se/ is a multi-disciplinary research facility based on the world's most powerful neutron source currently under construction on the outskirts of Lund in southern Sweden. ESS is one of the largest science and technology infrastructure projects being built today. The

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

facility's unique capabilities will both greatly exceed and complement those of today's leading neutron sources, enabling new opportunities for researchers across the spectrum of scientific discovery, including materials and life sciences, energy, environmental technology, cultural heritage and fundamental physics and addressing some of the most important societal challenges of our time.

Case 14 ESS In-Kind Concept: Target Wheel

The target wheel is a 2.6 m diameter stainless steel disk containing bricks of a neutron-rich heavy metal: tungsten. It weighs almost five tons. The wheel rotates at 23.3 RPMs, in time with the arrival of the proton beam painted across the exterior of the wheel shroud. The unit is cooled by a flowing helium gas system interfaced with a secondary water system. The tungsten wheel is a new technology for spallation sources, none of the established target designs being adequate for the higher power level of ESS

ESS Bilbao in Spain is responsible for this In-Kind delivery and is an internationally renowned strategic center for neutron technologies. The ESS Bilbao Consortium is run by two public administrations. On one side, there is the Spanish State Government, with a 64% stake, and on the other, the Government of the Basque Autonomous Region, with a 34% stake.

The workforce at ESS Bilbao is made up of around 60 highly qualified experts in the fields of physics and engineering. The organizational structure of the ESS Bilbao Consortium is broken down into topic-based groups, each with its own specific work projects.

The particular added value that ESS Bilbao offers to the society around it is the knowledge that it generates in the accelerator, target and neutron generation fields.

The European Research Infrastructure Consortium for CO2 capture ECCSEL ERIC www.eccsel.org enables open access to a world class research infrastructure in Europe for carbon capture, transport, storage and utilisation (CCUS) researchers and industry across the world). ECCSEL facilitates and coordinates requests for access to facilities within the ECCSEL Research Infrastructure. The mission of ECCSEL is to reach out to relevant industry and research communities to determine their research infrastructure needs to enable full-scale deployment of CCUS in Europe. The ECCSEL Consortium currently consist of five European countries.

Case Study 15 Enabling zero CO_2 emissions

ECCSEL is a distributed research infrastructure with 20 facility owners in the consortium. ECCSEL ERIC consist of over 80 research facilities and continues to grow. Now, ECCSEL is in a transition phase from solely offering the service of open access to research facilities, to a more advanced level of services. This is done mainly through the **ECCSELERATE project**, where a central activity is increased industry collaboration in order to step up the services offered to industry and research communities. Enabling these focus areas to expand is expected to contribute to the overall vision of ECCSEL, to enable low to zero CO2 emissions from industry and power generation through research that will provide cost effective CO2 capture, transport, storage and utilization technologies. ECCSEL ERIC is advancing in the central focus of collaboration with industry through Horizon Europe pillar 2 engagement. The launch of the Partnerships Processes4Planet, Clean Steel Partnership and Clean Energy Transition Partnership constitute arenas for expanded use of the ECCSEL Infrastructure. Working in close connection with the Strategic Research and Innovation Agendas of the European Partnerships secures that ECCSEL ERIC maintains the right research priorities towards our research facilities. Likewise, research priorities deriving from the ECCSEL community is also used as input for coming Work Programmes in Horizon Europe.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

LifeWatch ERIC https://www.lifewatch.eu/ is the e-Science European Research Infrastructure for Biodiversity and Ecosystem Research, a distributed Research e-Infrastructure to advance biodiversity research and to provide major contributions in addressing the big environmental challenges, such as the impact of Climate Change on Earth Biodiversity and Ecosystem Functioning. This goal is achieved by providing access through a single infrastructure to a multitude of sets of data, e-services and tools enabling the construction and operation of Virtual Research Environments (VREs), which allow the accelerated capture of data with new innovative technologies and knowledge-based decision making-support for the management of biodiversity and ecosystems.

Case 16 Agroecology living labs and research infrastructures

LifeWatch ERIC is to date the unique ESFRI-ERIC involved in the co-design and establishment of a partnership aimed to accelerate the transition towards sustainable, climate and ecosystem-friendly farming practices by enabling to better grasp short to long-term agroecological processes from farm to landscape levels, by boosting place-based innovation in co-creative environments ensuring farmers and other key stakeholders' engagement (including consumers) and by improving the flow and uptake of knowledge and innovations on agroecology across Europe.

LifeWatch ERIC is a key partner of the ALLReady CSA Consortium, and actively collaborates with the Strategic Working Group on Agroecology (SCAR-AE), DG AGRI (Unit B-2), DG RTD, JRC, etc., among other relevant stakeholders. LW ERIC is responsible of the construction of the knowledge and data management, which will be supported by computational capacity and e-Tools in the form of a Virtual Research Environment (Tesseract VRE). In fact, Agroecology research and innovation network scaling up from local to the global one is a complex process. Responding to this complexity is a major driver on the data and knowledge management perspectives, which require important efforts on the harmonisation, integration and interoperability, taking into account the connectivity with the rest of work packages in terms of drivers and variables considered. In order to achieve this main aim, a demonstrator, in the form of a Virtual Research Environment, integrating and providing LifeBlock(-chain)-based technology and other e-Services has been developed jointly with the data management plan (DMP) and other innovative tools, by also following FAIRness principles agreed by the ENVRI FAIR cluster Communities-of-Practice Members. In addition, the proper IPR management policies and recommendations have been also produced.

3. EU research innovation, competitiveness and sustainability

RIs contribute to structuring the European Research Area by participating in ambitious pan-European crosscutting thematic networks expanding thus their reach and impact across sectors to bridge knowledge gaps and strengthen collaborations to address scientific challenges that need to be undertaken at the global scale.

The Joint Institute for Very Long Baseline Interferometry (VLBI) JIVE ERIC https://www.jive.nl/ is the central organization in the European VLBI Network (EVN), supports the operations of the EVN as a facility and implements the core data processing and user services that are essential to turn the network of distributed telescopes into a single observatory to study the radio sky at the highest possible resolution. JIVE ERIC serves as a catalyser for a broad range of Research and Development activities in VLBI-related fields, creating new value and exploiting capabilities that would not be possible by individual partners.

Case Study 17 Deciphering global radiodata in real-time

The **EU FP7 eInfrastructure project *NEXPReS***, coordinated by JIVE ERIC, allowed the introduction of a real time (e-VLBI) component to every experiment, aiming for enhanced robustness, flexibility and sensitivity, boosting the

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

scientific capability of this distributed facility and offering better data quality and deeper images of the radio sky to a larger number of astronomers. *NEXPReS* developed high-speed recording hardware, as well as software systems that manage the process and hide all complexity. Real-time computing in a shared infrastructure and dynamic bandwidth and high-capacity networked storage on demand was also addressed to improve the continuous usage of the network and prepare the EVN for the higher bandwidths to ensure it remains the most sensitive VLBI array in the world. Currently, the e-EVN is still the only VLBI network in the world capable of real time observations, and provides enhanced scientific performance for all users of the EVN and its partners.

The European Multidisciplinary Seafloor and water column Observatory EMSO http://emso.eu/ is a distributed European Research Infrastructure based on an integrated system of Regional Facilities. It is aimed at the long-term multidisciplinary observation of the seafloor and the water-column by means of multi-sensor platforms deployed in scientifically relevant key sites of the European seas. EMSO's main scientific objective is the observation and recording of biogeochemical, and physical variables, at an unprecedented resolution, with the ultimate goal to understand the complex interactions between the geosphere, the biosphere, the hydrosphere, and atmosphere and address the main environmental challenges affecting the Earth System like of Climate Change, biodiversity and marine Ecosystems and Geo-Hazards.

Case Study 18 Continuous-time monitoring of the ocean to decipher environmental patterns

X_EMSO provides continuous time-series multidisciplinary data (https://data.emso.eu/home), going from the sea surface to the deep seabed, and sub-seafloor address many key processes that affect the entire ocean. The volume of data and information provided by EMSO ERIC allows the description of processes ranging from extreme episodic events to slow trends, difficult to distinguish from the underlying variability of short-term processes. The continuous, high-resolution, long-time-series collection of multiple variables at chosen fixed sites across a breadth of environments pursued by EMSO, allows for the development of new approaches to shed light on the complexities of the Earth System.

Analysis and Experimentation on Ecosystems AnaEE https://www.anaee.eu/ is the European Research Infrastructure that brings together state-of-the-art experimental and analytical platforms for ecosystem research throughout Europe. By linking these platforms for modelling approaches, AnaEE advances our understanding of the environmental impacts of ongoing global change, and fosters adaptation and mitigation strategies for safeguarding ecosystem services, as well as their societal and economic benefits. This has an impact on agriculture, management of forests, and also on evidence-based policies.

Case Study 19 Keeping the functions and services of Ecosystems in the Anthropocene

Ecosystems services are crucial for food security, human health, and welfare. It is essential to keep their functions active to face the challenges of the Anthropocene, such as biodiversity conservation, greenhouse gas reduction, carbon sequestration, ensuring drinking water quality and quantity, and food production. Experimentation and modelling are of uttermost importance to understand the functioning of ecosystems and their behavior under anthropogenic pressures such as climate change, pollution, land use and management practices. New management practices and evidence-based policies for adaptation and mitigating the negative impacts, can be proposed and tested thanks to modelling and experimentation under realistic conditions, simulating various possible global change scenarios.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Case Study 20 Adaption to Climate Change impacts on Ecosystems and biodiversity

The warnings of 15 000 scientists, of the United Nations Paris Climate Change Conference (COP21) and now of the UN Global Assessment Study clearly demonstrate that humanity is bringing our life support system, the biosphere, to the point of collapse. Counteracting the current loss of biodiversity and the accelerating rate of species extinctions must become our highest-priority, not only for ecological and environmental reasons, but because the ecological collapse of the biosphere is already a major underlying cause of poverty, increasing social inequalities, growing global economic uncertainty, and conflicts over access to crucial natural resources, like clean water, food, air and energy supplies. The first steps in tackling this crisis must be to improve our current level of knowledge, to move beyond the present fragmentation of science, and to foster greater complementarity and synergy between disciplines, by developing new inter-disciplinary paradigms and starting to build synthetic knowledge, so as to boost innovation and involve more young scientists and civil society.

Certainly, biological invasions are listed as one of the five major causes of biodiversity loss, alongside habitat destruction, over-exploitation, climate change and pollution (Millennium Ecosystem Assessment, 2005), and measures to control their introduction and establishment are urgently needed (Aichi Target 9; CBD 2010). Nevertheless, risks of invasion are increasing rapidly on a global scale owing to expanding transportation networks, technological advancements, landscape transformation and climate change (Galil 2015; Seebens et al., 2015; Early et al., 2016). Global change, causing progressive shifts in the ecosystem niche dimensions, are currently imposing disequilibrium conditions to ecosystems, unsaturated niches and threats or opportunities for species range restrictions or expansions. According to current global change scenarios (IPCC V Report, 2015), increasing proliferation of species range expansions and pure biological invasions seem to be very likely in the next decades. The negative impact of alien species invasion on ecosystem integrity is well documented, affecting both the structural and functional properties of ecosystems, such as native species abundance and range, native population space use, behaviour and energetics, community composition and diversity, ecosystem processes and functioning and ecosystem services (Peichasr and Mooney, 2009; Vilà *et al*., 2010; Vilà *et al*., 2011; Simberloff *et al*., 2013).

For that reason, LifeWatch ERIC is Europe's first line of response to this emergency, applying and advancing ICT technologies, web networks, interconnecting scientific communities and research centres internationally into its web-based research infrastructure. This has been achieved through the launch of an Internal Joint Initiative on Non-endemic and Invasive Species (IJI-NIS acronym), with the main pilot study cases engaged in the corresponding Tesseract Virtual Research Environment, jointly with the associated LifeBlock-chain and other applications.

Case Study 21 Blockchain technology for the environmental community

LifeBlock is the Blockchain platform design, constructed and deployed by LifeWatch ERIC to provide “anti-tampering” provenance, and traceability e-Services by also guaranteeing the availability of FAIR (Findable-Accessible-Interoperable-Reusable) compliant resources: data and software, but also publications and media.

LifeBlock stores, manages and gives access to a variety of data and ecosystem applications addressed to all types of organizations and communities of practice. It is a network which can scale autonomously and independently without the need of any central control body, due to the characteristics of distributed databases of Blockchain architectures. In fact, each new organization that joins the environment will store its data and make it available to the community, while it will store other data from other organizations using the distributed characteristics of Blockchain. Additionally, a token management mechanism has been implemented based on Smart Contracts applications, so that the associated tools for aggregation/access/data management are in the public domain and can be used by any organization for both

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

data availability and navigation or download. As an interesting application, it is worth to mention the application of the LifeBlock tokenization mechanism for the socio-economics valorization of Ecosystem Services.
LifeBlock is an essential part of Tesseract VRE, the Virtual Research Environment platform developed by LifeWatch ERIC in tightly collaboration with the rest of ENVRI FAIR cluster Communities-of-Practice Members.

Case Study 22 Clinical research Initiative for Global Health

CRIGH Clinical Research Initiative for Global Health https://crigh.org/: **ECRIN** supports multinational clinical trials in Europe where a favourable ecosystem enables cooperation (partial regulatory and ethical harmonisation, availability of funding for multinational trials etc). However, there is a real need for global cooperation, in particular for trials on rare diseases, or during health outbreaks as illustrated by the COVID crisis. ECRIN therefore contributed to the launch in 2017 of the CRIGH including more than 40 global partners with the objective of developing common tools, practice and training and to facilitate global cooperation

4. Bridging funding schemes towards sustainability

Over the course of the past decade, the ERICs have become key instruments for cutting-edge science that provide solutions today's major socio-economic and environmental challenges, underpinning the development of the ERA and fostering multinational and transnational cooperation. Funding from diverse schemes, together with the invaluable contributions of ERIC member countries, have allowed ERICS to deliver access to services, facilities, samples and data across Europe. With the future of the ERA at our doorstep, ERICs must continue to evolve and expand their outreach, while upholding the highest standards of scientific excellence. Funding schemes that can sustainably provide resources in sufficient volumes will be essential. A continuous and open dialogue between ERICs and all funding bodies is required to identify and adopt solutions that will lead to the optimized and sustained use of ERICs. A dedicated working group w within the ERIC Forum shall continue to study these questions and reflect on pragmatic solutions. Coherent and synergic actions between the national, regional and European funding bodies will lead to a more efficient and strategic use of resources at every level, placing ERICs at the forefront of the renewed ERA. The collaboration between the EU Commission and the Member States in the continued evolution of the ERIC Regulation, is also required to define and optimize the funding volume and mechanisms supporting the broad variety of ERIC operations models. A sustained effort from ERICs in their evaluation and assessment of their funding models will contribute to a fruitful and productive dialogue.

Case 23 Mobilizing European Regional Development Funds (ERDF) for ERICs

The Spanish government allocated 51,2 M€ ERDF[12] funds to the Andalusia Region. As a consequence, the total budget allocated to actions, as co-financed by the 80%-20% co-funding rule, for activities related to LifeWatch ERIC is 64 M€. Specifically, this fund should be used between 2020 and 2023.
The most innovative aspect of this call is that it ensures the use of funds for internationalization purposes channeled through an ERIC. In this call, at least, 36% of the overall project budget must be allocated to the Internationalization of R,D&I activities developed and/or carried out by LifeWatch ERIC in collaboration with other Research Infrastructures (other ERICs, EOSC, Copernicus, etc.)[13].
Several projects have been submitted in response to this call. The start of the selected projects was planned to start in May 2020. Nevertheless, the implementation is suffering a reasonable delay due to COVID-19. In any case, these

[12] *European Regional Development Fund https://ec.europa.eu/regional_policy/en/funding/erdf/*
[13] *1st Technical and Innovation Report: Creating synergies between ERICs and the (Regional) Research and Innovation Strategies for Smart Specialisation -RIS3 ADD LINK*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

funds have been properly approved, upgraded and put in relation with the pandemic[14], so that these projects have been recently started.

Case Study 24 EPOS Sustainability Project

EPOS is currently working on implementing four main areas to achieve the final goal of moving from financial viability to long-term sustainability (EPOS Sustainability Project[15]):

1. Financial, dedicated to strengthen financial sustainability, through the consolidation of EPOS ERIC memberships, the engagement of new countries in EPOS and the harmonization of EPOS data and service provision with national strategies and funding.

2. Technical and Innovation, by securing sustainable data and service provision within the EPOS Delivery Framework, by contributing to the sustainable operation of the EPOS e-infrastructure, and by fostering innovation for the implementation and use of the EPOS e-infrastructure.

3. Excellence, through the cooperation of EPOS with similar worldwide initiatives on interoperability of geoscience data; through international cooperation to foster the multidisciplinary use of solid Earth science data; through user engagement to create awareness on multidisciplinary data and services accessible through EPOS; and through user training initiatives describing the available services in EPOS to create awareness on the potentiality of solid Earth science data to answer ground-breaking scientific questions.

4. Economic and Societal, by defining a sustainable, ethically coherent way to provide services and scientific information to society; by implementing a strategy for socio-economic impact assessment and for a sustainable cooperation with the private sector.

CONCLUSIONS AND CHALLENGES

The diversity of the RI landscape, the differences in size, scope and activities underscore the integration endeavors undertaken at multiple levels by the RI community with their national and European stakeholders to highlight their common challenges and shared interest in overcoming them. Targeted hands-on guidelines, toolkits and recommendations developed within RIs and with different stakeholders provide insight into the needs of European RIs in order to flourish and the required next steps. The following hurdles have been identified for the successful upscaling of Big Science through ERICs within the current landscape and need to be addressed collectively:

1. Competition between RI and partners

In cases where the ERIC can develop activities or projects which are of interest of individual partners, conflicts of interest may arise. The partner could force the ERIC to avoid the competition, which may compromise the interests of other partners.

This may affect especially small partners/countries, which may not have sufficient own infrastructures and depend much more on the ERIC to develop the activity. The EC could mediate in such cases, if this capacity is included in the ERIC regulations.

2. Visibility of the ERIC

14 https://www.ciencia.gob.es/stfls/MICINN/Ministerio/FICHEROS/Plan_de_choque_para_la_Ciencia_y_la_Innovacion.pdf, *see page 19.*

[15] *The EPOS SP (Sustainability Phase) project that has been funded by the EU Horizon 2020 under Grant Agreement no. 871121 to perform activities aimed at ensuring the long-term sustainability of the EPOS Research Infrastructure as the Europe's key Research Infrastructures for the Solid Earth Science.*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Visibility of ERICs needs to be improved, both at the Member States (policy makers, funding agencies) and also researchers' level. Proper acknowledgement of the RI in the research results and publications is required, to help demonstrate the impact of the RI. It will be beneficial to create outreach material for the ERIC nodes, also in the local language. Proactive awareness of the editors of scientific journals may help ensuring that the RIs are also properly recognized.

3. Lack of RI recognition as stakeholder

The Member State that hosts an ERIC, within the premises of its national RI, may not have developed the procedure to separate both with sufficient clarity. The ERIC is then seen locally as a "department" of the national RI. Moreover, there are signals that explicit visualization of the members may prevent the sense of integration (e.g. flags). The ERIC added-value must be known and recognized by the partners, to better engage their sense of belonging and ownership, and the EC must continue supporting the effort of integration (as with the INFRADEV calls), while being vigilant to ensure that all the partners respect the ERIC entities.

4. Member States support for RI: Access to national funding streams

While recognizing that ERICs have as per the ERIC regulations the capacity to act in the Member States, their current eligibility to access calls for national or regional funding is very diverse. There may be reluctance in some Member States that allowing ERICs to present projects may increase the competition for the limited funds. It is however important to note that the participation of the ERIC *together with* the national nodes could improve the quality of the project. The national rules for eligibility should accept the ERICs, which would be beneficiary only if applying to the calls in coordination with the national RI [16].

5. Inclusion in European Research funding schemes

The ERICs are mainly supported by the Member States, however the EC must also maintain its role beyond the preparation phase, e.g. through the INFRADEV contracts, demonstrating interest, supporting sustainability and protection of the international collaboration. Currently, the great majority of the calls for proposals targeting Research Infrastructures in Horizon Europe addresses groups of RIs and asks them to integrate their services to contribute to solving grand challenges such as cancer, infectious diseases or transition towards a sustainable agroecology. In further support for the implementation and sustainability of these initiatives, creating productive cross-linkages, especially through different domains should be taken into consideration and strengthened. In addition, and complementary, in order to fully reap the benefits of the investments in RIs, support to curiosity-driven research should continue to be provided via grants to individual RIs (e.g. via INFRADEV calls).

6. Legal constraints

European countries in order to become full members in an ERIC need to accept the ERIC regulations, which impose some conditions that may not be accepted (e.g. the recognition of the EU Court of Justice). This is difficult to avoid, however, it is possible to engage in an ERIC in different forms, like participation regulated by a MoU, which could set a favorable context for the collaboration.

7. Collaborations with Industry and SMEs

[16] *ERIC Forum Policy Brief Funding Models for Access to ERIC Multinational/ Transnational Services https://www.eric-forum.eu/wp-content/uploads/2020/09/ERIC-Forum_Policy-Brief.pdf*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

Companies collaborate with ERICs as users, suppliers and co-creators, benefitting from the expertise, technology development and access to an unprecedented large network of researchers. Access to the RI sophisticated expertise and instrumentation, usually at lower cost than through commercial services, particularly enhances the competitiveness of SMEs with limited capital funding. An ERIC may create an "industry board" and employ a dedicated industry contact officer to support continuous engagement with industry, organize joint events, increase visibility of the RI or support commercial users of RI services. RIs such as Euro-BioImaging already have a formal Industry Board established, which strengthens the link between technology developers and users and provides feedback to the RI on industry-relevant topics and technological trends from an industry perspective. In addition, by creating a "ERIC label", industry could highlight collaborations to increase visibility and grow the reputation of both companies and RIs.

8. Sustainability of RIs

The necessity of pursuing long-term sustainability calls for constant revision of an ERIC Business Plan. Sustainability is conditioned by multiple facets (legal, governance, technical, scientific, financial) and by multiple stakeholders (users, national RIs, governments), all of them influencing the capacity of an ERIC to remain sustainable in time. This is particularly challenging in the case of distributed research infrastructures, where the number and diversity of contributors requires a high level of coordination and synchronization of resources.

9. Translation of science results in policies

The impact of research performed thanks to ERICs is often of societal and economic nature. Examples are numerous such as ecosystems and biodiversity conservation, climate change, clinical research, sociology, agronomy, etc. ERICs have a broad view on the individual research project performed on their premises, are of European nature crossing the national boundaries. Therefore, they are the actors of choice to write synthesis of the results with impact to the society at large, and they can provide advice to the regulators and policy-makers. Moreover, as many of the theme challenging the society are of interdisciplinary nature, as climate and biodiversity, or human-virus interaction and ecosystems, the cooperation between ERICs is needed.

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

RECOMMENDATIONS

The main challenges identified to unlock the potential of ERICs as Big Science enablers are both material and intangible and thus require a multipronged approach for optimizing the research ecosystem to facilitate knowledge transfer and operational implementation, to boost competitiveness and support the upscaling of projects to tackle pressing global societal challenges. The following recommendations summarize the points raised and illustrated through the case studies presented in this policy brief.

1. The benefit and added value of the ERIC should be manifest when engaging in projects or activities in which individual partners have interest, in order to avoid conflicts of interest.

2. The role of pan-European research infrastructures as Big Science instruments among the public research communities and the industry should be highlighted.

3. Large-scale interdisciplinary collaboration should be promoted across RIs and scientific communities mobilizing collective intelligence to prioritize research questions and the design of research protocols.

4. The operational and legislative frameworks for data standards, sharing, reuse and analysis should be strengthened.

5. Authorship rules, evaluation criteria and career development policies should be developed to promote the participation of research and infrastructure staff in large-scale, highly collaborative projects.

6. The participation of third-countries in ERICs, despite not endorsing the ERIC regulations, should be encouraged by other different forms, such as participation regulated by a MoU, which could set a favorable context for the collaboration.

7. Member State support for RIs should be promoted in projects funded by national programs in Member States, supporting the national node and increasing the quality and impact of the proposed activities. The national rules for eligibility should be adapted to allow acceptance of ERICs (which, for example, would be beneficiary only if applying to the calls in coordination with the national RI).

8. ERICs in any Member State, independently of the details of the hosting arrangements, must be clearly recognized as a distinct, international, established institution with its own legal entity as per the ERICs regulations, different from the national RI. The EC must be vigilant to ensure that all the partners respect the ERIC entities.

9. Funding mechanisms should be adapted to unfold the full potential of ERICs and to meet the needs of Big Science projects in terms of volume of funding, of multinational and cross-border availability, and of prioritization of large scale projects that will benefit from ERIC infrastructure support.

10. The EC must maintain its role and support ERICs beyond the preparation phase, through instruments such as the INFRADEV contracts, to support and facilitate international collaboration.

11. ERICs are valuable to the industry, increase the visibility of the collaboration by creating an “ERIC label” that the industry can exploit for reputation, and an “industry board” to maintain the link.

12. Global expansion or partnerships with ERICs should be promoted to foster collaborations in global research projects to tackle shared challenges.

13. Science-based policy-making should be supported by strengthening the dialogue between ERICs and policy-makers.

ERIC Forum has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N. 823798

APPENDIX

ABBREVIATIONS USED

DG AGRI Directorate General for Agriculture
DG RTD DG for Research and Innovation
EC European Commission
ENVRI Environmental Research Infrastructures
EOSC European Open Science Cloud
ERA European Research Area
ERDF European Regional Development Fund
ERIC European Research Infrastructure Consortium
ESFRI European Strategy Forum on Research Infrastructures
FAIR Findability, Accessibility, Interoperability, and Reusability
JRC Joint Research Center
LSRI Life Sciences Research Infrastructures
RD&I Research, Development and Innovation
RI Research Infrastructures

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

If delivery is late, enter here the explanation.

This deliverable initially planned for M30 (June 2021; following an amendment) is delivered belatedly on M35 (November 2021). This delay is in great part due to strategic decisions taken at WP and coordination level to align the activities of WP6 with WP4 (and their partner expert consortia) regarding outputs related to the socio-economic impact (SEI) of ERICs".

The second policy report topic *Socio-economic impact (SEI) of ERICs* was selected in M19 (July 2020) according to the consensual participative procedure described Deliverable D6.1. However, following a parallel WP4-WP6 initiative to synergize actions regarding SEI-related deliverables to optimize both the coherence and impact of our activities, and after WP6-wide consultation and vote, all WP6 members and the EF coordination agreed to align the delivery date of the policy brief *Socio-economic impact of ERICs* with that of Task 4.3 Report on SEI ERIC Framework. This selected topic was thus converted into the third policy brief to be delivered in 2022 with D 4.3 17. An amendment of the timeline for this deliverable is yet pending due to its omission by mistake in the previous amendment.

Hence the required relaunch of the selection process for the second topic for the WP6 policy (please refer to Deliverable 6.2 and 6.3). The topic *Scaling-up research projects through ERICs: impact of big science on the research ecosystem* was selected by the WP6 FLTF members in M23 (November 2020) with the delivery date in M30 (June 2021).

The updated delivery timelines of both these reports (D 6.5 to 6.9) were agreed to be communicated to the EU Project Officer as discussed during the TCs with WP6 and the coordinator to take into account the processes and time required for deliberation, voting and timeline alignment.

Discussion and Conclusions

Discuss and conclude your results.

The writing up of the second WP6 draft policy brief brought together once again the ERIC FORUM community to jointly address a topic of critical interest for ERICs to better inform the relevant European policy and decision-making bodies, helping to expand their impact and their contribution to an innovative and sustainable European Research Area within the goals set out in the ERIC FORUM project:

1. Aim at strengthening coordination and networking reinforcing the informal ERIC network or its successor framework;
2. Support the organization of specific meetings, targeted thematic workshops focusing on shared challenges;
3. Support ERICs in preparation;
4. Support common communication and outreach activities and strengthening external representation of ERICs' as a stakeholder in consultations and other policy actions that could affect them.

In total 16 RIs from all ESFRI domains participated in drafting this policy brief and provided 24 case studies showcasing their activities in upscaling Big Science.

[17] *The mentioned timelines are recorded in minutes of WP6 meetings dating from December 2020 as well as the presentations during the ERIC FORUM Management Meetings 2020-2021 available on the EF sharepoint.*

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798

ENERGY	ENVIRONMENT	HEALTH &FOOD	PHYSICAL SCIENCES & ENGINEERING	SOCIAL SCIENCES & CULTURAL CHANGE	DIGITAL	TOTAL
ECCSEL	*EMSO* LIFEWATCH EPOS	EURO Bioimaging BBMRI ECRIN INSTRUCT EU OPENSCREEN EMPHASIS AnaEE EMBRC	JIVE ESS Spallation	CESSDA ESS-social		
1 6%	3 18%	8 50%	2 12%	2 12%		16 100%

Next Steps

Include the future work to be undertaken and recommendations.

Given the delayed delivery of this second policy brief, explained above, the timeline for the organization of the yearly seminars to finalize the brief shall be discussed within WP6 and with the ERIC FORUM coordination. These seminars were planned to take place back-to-back with the ERIC FORUM Annual Meeting.

If due to timeline constraints a dedicated seminar cannot be organized with all the key stakeholders in collaboration with an ERIC/ESFRI/RI event to present the policy brief, then an email consultation shall be arranged to ensure that the policy brief benefits from the relevant expert insight outside of ERIC FORUM and is not produced in a silo. The same approach shall be taken for the final policy report during 2022 (Y4).

References

ERIC-FORUM Deliverables 6.1 Defining Priorities Year 1, 6.2 Defining Priorities Year 2 and 6.3 Defining Priorities Year 3

Appendix I

1. Minutes TC1 with timeline and participation
2. Writing Team Composition

ERIC Forum has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N. 823798