European Commission

Supporting the Transformative Impact of Research Infrastructures on European Research

Report of the High-Level Expert Group to Assess the Progress of ESFRI and Other World Class Research Infrastructures Towards Implementation and Long-Term Sustainability

Independent Expert Report

Research and Innovation

Supporting the Transformative Impact of Research Infrastructures on European Research

European Commission
Directorate-General for Research and Innovation
Directorate G — Research and Innovation Outreach
Unit G.3 — Research and Innovation Infrastructures

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Manuscript completed in June 2020.

More information on the European Union is available on the internet (http://europa.eu).

Print	ISBN 978-92-76-19271-8	doi: 10.2777/490221	KI-02-20-397-EN-C
PDF	ISBN 978-92-76-19272-5	doi: 10.2777/3423	KI-02-20-397-EN-N

Luxembourg: Publications Office of the European Union, 2020

EUROPEAN COMMISSION

Supporting the Transformative Impact of Research Infrastructures on European Research

Report of the High-Level Expert Group to Assess the Progress of ESFRI and Other World Class Research Infrastructures Towards Implementation and Long-Term Sustainability

High-Level Expert Group

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2020

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Europe has a well-established tradition of scientific excellence of globally competitive large-scale Research Infrastructures (RIs). It has built a worldwide reputation in research and unlocked its innovation potential in various domains. The RI system, promoted and supported by the European Union (EU), has contributed to transforming the way science is done in Europe with an emphasis on collaboration, inclusiveness and open, merit-based access to world-class infrastructures across the research landscape. RIs are providers of new knowledge for pursuing complex goals as identified in the missions of Horizon Europe (HE).

To maintain and strengthen such a leading position, the constant development of research, scientific and innovation skills, state-of-the-art facilities and related activities is crucial. Research Infrastructures play an essential role in enabling the broadest community of researchers to perform disruptive research, discovery, technology development and invention thus advancing competences, innovation and competitiveness.

It is therefore important to assess the state of play of the pan-European RIs and the effectiveness of the investments in promoting and operating them and to identify the most favourable pathways towards their Long-Term Sustainability (LTS).

This High-Level Expert Group (HLEG) was assigned the task of assessing the effectiveness of the EU measures supporting the development of a well-balanced and competitive European Research Infrastructure system. The HLEG was also asked to assess the implementation of a representative group of RIs and their plans for ensuring LTS.

The findings, reported here indicate that, overall, European Commission funding instruments have been effective in supporting a number of crucial activities across the RI lifecycle. In particular, the funding instruments have been very effective in supporting the 'bottom-up' stages of the lifecycle. However, issues of misalignment of national roadmap exercises and funding plans for RIs need to be overcome to make the implementation of the full RI system supporting the European Research Area (ERA) more time efficient and cost-effective. Despite long-term sustainability being increasingly emphasised in EU funding instrument call texts, this issue remains challenging for the vast majority of RIs. We find that few RIs outside the European Intergovernmental Research Organisation forum (EIROforum) grouping are able to demonstrate the characteristics required to achieve long-term sustainability. In addition, we note that unique research infrastructures are also operated by networks and that the full deployment of competitive research services in Europe cannot be pursued by implementing an ever-growing number of autonomous legal RI entities.

Our findings suggest that future Horizon Europe funding instruments should address LTS early in the lifecycle of RI development. To this end this report makes a number of recommendations.

- A staged approach with funding targeted at helping RIs to move through defined lifecycle stages or readiness levels, with checkpoints to verify progress, should be adopted.
- A panel of independent experts should be set up by the EC in collaboration with the European Strategy Forum on Research Infrastructures (ESFRI) to assess and verify progress at the end of each FP-funded grant or contract and to recommend future actions. Guidance and templates should be developed for reviewers and experts to operationalise this when new proposals are submitted, and later assessed.
- The fact that a RI is on the ESFRI roadmap should not lead to an automatic expectation of financial support from the EU. The RI should fulfil certain criteria and should show the progress made before applying for the next round of funding support.
- To allow for more effective proposal reviews, a 'dossier' for each RI should be created tracking its funding history and successful achievement of its own goals against its schedule. The RI-dossier should be the reference for all assessments.
- In order to improve the prospects for sustainability, the EU should insist on Member States' contributions to the funding of Preparatory and Implementation Phases with a significant element of this funding being provided as cash.
- Projects should be encouraged to work to increase financial commitment from MS alongside political endorsement.
- Integrating Activities (IAs) have been key to the development of RIs and their services. A clear way forward for those IAs that could realise important RI services, without creating new entities – RIs, European Research Infrastructure Consortiums (ERICs) or similar –should be considered by the EU to enable valuable networks to continue to operate effectively.
- The requirement on RIs to align to, and actually contribute to the definition of, the European Open Science Cloud (EOSC) services and operational instruments requires a higher level of coherence in the funding from different chapters (RTD, CONNECT) of the Framework Programme, and across the three pillars of Horizon Europe.

INTRODUCTION

In January 2019, the European Commission's Directorate-General for Research and Innovation (DG RTD) set up a High-Level Expert Group to assess the progress of ESFRI and Other World Class Research Infrastructures towards implementation and long-term sustainability (see Annex 1 for the full Terms of Reference for the Group). The group was comprised of six independent experts (including a chair and a rapporteur), acting in a personal capacity. The work of the group was supported by the staff of DG Research and Innovation, Unit G3 'Research and Industrial Infrastructures' of the Directorate G 'Research and Innovation Outreach'.

The group was tasked with carrying out its work from January 2019 to December 2019 focusing on two objectives:

Objective 1: to assess the effectiveness of the Research Infrastructures funding instruments under the European Union's Framework Programme for Research and Innovation; and
Objective 2: to assess the RI progress towards implementation and long-term sustainability.

Under Objective 1, the group's task was to assess the effectiveness of the Framework Programme funding instruments, in particular the Preparatory Phase (PP) funding for RIs in the early phases of their lifecycle, the individual support for fostering their implementation and enhancing their sustainability. The purpose of this assessment was to provide recommendations, where appropriate, for the improvements in the funding instruments, which set the foundations to help RIs to move towards sustainability.

Under Objective 2, the task was to evaluate the future outlook of the RIs of pan-European (or global) relevance in relation to their scientific goals and the evolution in their lifecycle; identify major bottlenecks and possible measures which might impact their further development; and to provide recommendations on the basis of the assessment and evaluation in line with the long-term sustainability pre-conditions[1], namely:

[1] The European Commission Staff Working Document SWD (2017) 323 and the preceding consultation process were based on interrelated conditions for sustainability of RI:

- Ensuring scientific excellence
- Attracting and training the managers, operators and users of tomorrow
- Unlocking the innovation potential of RI
- Measuring socio-economic impact of RI
- Exploiting better the data generated by the RI
- Establishing adequate framework conditions for effective governance and sustainable long-term funding for RI at every stage in their life-cycle
- Structuring the international outreach of RI

- critical mass and added value of the RI (in comparison with a network) and prospection of new members,
- key Performance Indicators and Socio-Economic Impact,
- catalogue of services and service-driven approach,
- user communities and outputs also in terms of innovation and Technology Readiness Levels (TRLs),
- capacity to maintain leadership and excellence in terms of instrumentation and services in relation to scientific and technical developments,
- complementarity of the activities of the RIs and possibilities for consolidation with overlapping/related RIs,
- effectiveness of embedding international partners in the RI and of the cooperation with relevant international partners.

The Terms of Reference for the HLEG noted that 57 RIs had been identified to be of pan-European (or global) relevance. These were the 55 RIs that are included in the ESFRI Roadmap (37 Landmarks, 18 Projects) and two European Research Infrastructure Consortiums (ERIC), CERIC ERIC and JIVE ERIC. The list of the 57 RIs studied is provided as Annex 3 to this report.

During the first stage of the HLEG activity, which took place between March and August 2019, to address Objective 1 (assessing the effectiveness of the Research Infrastructure funding instruments under the Union Framework Programme), the focus of the HLEG's work was on a subset of 49 RIs. The EIROforum were not studied at this stage along with some special cases such as nuclear RIs (JHR, MYRRHA) and PRACE that are differently guaranteed in terms of sustainability and were not considered further.

During the second stage of the HLEG activity, which ran from September 2019 to January 2020, the 5 RIs managed by EIROforum members were assessed as a separate group due to the different conditions for their long-term sustainability. Out of the remaining 49 RIs, those 6 that entered the ESFRI Roadmap in 2018 were excluded, leaving a list of 43 RIs to be individually assessed to address Objective 2 (assessing the RI progress towards implementation and long-term sustainability).

This report summarises the findings of the HLEG during both stages and provides sets of recommendations aimed at improving future funding instruments of the Union Framework Programme and the implementation and long-term sustainability of the individual RIs.

Landscape

Research Infrastructures and Long-Term Sustainability

Europe has a long tradition of scientific excellence, has built a worldwide reputation in research and unlocked its innovation potential in various domains. To maintain and strengthen such a leading position, the constant development of research, scientific and innovation skills, state-of-the-art facilities and related activities is required. Research Infrastructures play an essential role in enabling discovery, technological development and invention and, thus, advancing science, technology, and innovation.
The concept of developing an advanced Research Infrastructure system is that only by enabling the broadest community of researchers to perform their work with the most advanced tools, new disruptive science can develop and the scientific return on investment can be maximised. RIs are therefore complementary to specific mission-oriented undertakings that involve typically only dedicated staff scientists and collaborators.

The term 'Research Infrastructure' refers to facilities, resources or services of a unique nature that have been identified by European research communities to conduct top-level activities in all fields of science. This definition includes the associated human resources, covers major equipment or sets of instruments and knowledge-containing resources such as collections, archives and data banks. RI may be located at a single site (for example, large telescopes or synchrotron light sources) or can be distributed across a large number of sites working jointly (for example, biobanks, archives or marine stations).

Research Infrastructures of various sizes ranging from large-scale, single-sited facilities and distributed infrastructures of pan-European relevance to mid-size national facilities, have benefited over the years from the European Commission's support. This has been provided through dedicated funding instruments under the EU Research Framework Programmes and from European Regional Development Funds (ERDF). National investments have also been crucial in the development and implementation of RIs. The composition and proportion of funding between EU instruments and national sources varies significantly between different RI types and between different stages of RI development. The different funding sources play an important role and the combination of efforts from Member States (MS) and the European Commission is needed to optimise the implementation and construction process of pan-European RIs.

To help bring together the strategic planning and investment decisions of the Member States and the European Union (EU), the European Strategy Forum on Research Infrastructures was established in 2002 with a mandate from the EU Council to support a coherent and strategy-led approach to policy making on Research Infrastructures in Europe, and to facilitate multilateral initiatives leading to the better development and use of Research Infrastructures, at EU level. ESFRI is a self-regulated body whose delegates are senior science-policy officers representing the ministers responsible for research in their country. The EU is represented by a senior officer from the European Commission. Notwithstanding this membership, recommendations of ESFRI, elaborated to fulfil the general and specific mandates periodically formulated by the Council, are not binding on the Member States or the EU.

In adopting the ESFRI Roadmap, Member States and Associated Countries identify those RIs that are strategically needed for European scientific competitiveness and support the plan for implementing them, paying highest attention to the sustainability aspects of each individual RI and of the ensemble of the pan-European RI Landscape.

The first ESFRI roadmap was published in 2006 and regular updates have been made since that time, with the latest version appearing in 2018. In 2013[2] The High-Level Assessment Expert Group (AEG) reviewed the projects on the ESFRI Roadmap. In light of their recommendations, entry onto the roadmap was made subject to meeting clear criteria. In addition, ESFRI established evaluation, assessment, monitoring and periodic review mechanisms that included independent peer review. Entry criteria were substantially strengthened in 2014 and enforced in the 2016 Roadmap update. The entry criteria were further refined for the 2018 and 2021 Roadmap updates.

As the Research Infrastructure landscape has expanded over the years, ESFRI has developed a medium to long-term vision of the needs of the European scientific communities. Over this same period, the ERIC Regulation have contributed to the structuring of the European RI ecosystem and the Joint Research Centre (JRC) Strategy 2030[3] has led to the European Commission's decision to open up its unique Research Infrastructures for external users. With such a rich and fast expanding RI landscape and portfolio, increasing financial obligations fall on Member States and national budgets. The collaborative relationship between the Member States, ESFRI and the European Commission has proved invaluable for developing a coherent strategy for Research

[2] Assessing the projects on the ESFRI roadmap – A high level expert group report
https://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/esfri.pdf

[3] The European Commission's science and knowledge service – Joint Research Centre Strategy 2020

https://ec.europa.eu/jrc/sites/jrcsh/files/jrc-strategy-2030_en.pdf

Infrastructure development and support, as demonstrated by the regularly updated Roadmap and its independent assessments of the progress of RI projects at each stage of their development. Investments in pan-European RIs have been better targeted as a result of this cooperation.

The Long-Term Sustainability of RIs has become a key agenda item for the EU, the Member States and ESFRI. The topic was first flagged at the Informal Competitiveness Council of July 2014 when the Council stressed that "open access to RI and data, better links with industry as well as policy prioritisation based on a multi-level approach, at national, European and international level, were key to ensure sustainability". In May 2016, the Competitiveness Council asked the European Commission to develop a long-term sustainability Action Plan. As a result, in September 2017, the EC launched a Commission Staff Working Document 'Sustainable European Research Infrastructures – A Call for Action'[4], which provided an in-depth exploration of key sustainability elements. The report was published in parallel with the 'Long-Term Sustainability' ESFRI Scripta series Vol. 2, which proposed seven main recommendations broken down into 35 detailed specific points. Based on the findings from these reports, long-term sustainability was clearly emphasised in the Research Infrastructures Work Programme 2018-2020, especially in the call 'Development and long-term sustainability of new pan-European Research Infrastructures' and the setting-up of this HLEG as an essential instrument in the monitoring and development of the Union policy on Research Infrastructures.

Research Infrastructures are designed to serve a science need and to enable a research community to be at the forefront of science with a timescale spanning two to five decades. This implies that at the time of kick-off of the implementation process, e.g. the entry in the ESFRI Roadmap, the investment plan must include a careful evaluation of the conditions that will ensure the expected return on investment in the future. The Member States and Associate Countries (AC) that promote a new entry in the ESFRI Roadmap should have a clear plan for the lifecycle of that RI, even though the fine details of the implementation process, as well as the real costs, will only truly emerge during the several many years of preparation and construction.

A sustainability plan, along with a constantly refined and updated cost-analysis, must be in place during all phases of the RI life-cycle, with specific and adjustable financial and governance architectures, along with periodic science strategy updates, to cope with the evolution of the partnership, internationalisation opportunities, different macroeconomic cycles, and emerging requirements from the evolving user community.

As Horizon Europe approaches, under the new post-2020 multiannual financial perspective, many challenges regarding further investment in Research Infrastructures,

[4] Sustainable European Research Infrastructures – A Call for Action, SWD (2017) 323

either on a European level or within individual EU Member States, remain. HE has the objective of consolidating the RI Landscape, opening, integrating and interconnecting them, which implies reinforcing European RI policy and international cooperation as well as connecting with the educational system. Furthermore, the European Open Science Cloud is expected to become an effective and comprehensive delivery channel for RI services and results, open to the widest community of beneficiaries and reaching beyond the research community.

Assessing the value of the current EC funding instruments and their potential refinement to optimise the chances of RI full deployment and long-term operation was the key objective of this HLEG during the first stage of our work.

Analysis of the Evolution of RI Funding

The decision to create or upgrade a Research Infrastructure is a MS and AC decision supported by strategic planning by ESFRI and the national roadmaping. This implies that MSs and ACs put in place dedicated resources. The EU however, has played a key role in prompting the harmonisation of the process towards the implementation of new and upgraded RIs and in facilitating access and exploitation by European researchers, through dedicated funding instruments stretching back as far as the 2nd Framework Programme for Research and Technological Development (FP2) where the concept of Transnational Access (TA) was first introduced. Under FP6 and FP7, in addition to TA, new actions were introduced including Networking Activities (NA) and Joint Research Activities (JRA), forming the Integrated Infrastructures Initiatives (I3), aiming to improve the quality of access offered in a field.

Framework Programme 7

The 7th Framework Programme for Research and Technological Development (FP7) ran from 2007-2013 with a total budget to support Research Infrastructures of EUR 1.7 billion. Under FP7, the RI-related funding instruments were grouped under the Capacities theme which aimed 'to enhance research and innovation capacities throughout Europe and ensure their optimal use'. The start of FP7 coincided with the publication of the first ESFRI Roadmap and based on this and the conclusions drawn from the implementation of the RIs programme in FP6 there were two lines of Actions followed in FP7[5]:

[5] Interim Evaluation: Analyses of FP7 supported Research Infrastructures initiatives in the context of the European Research Area
https://ec.europa.eu/research/evaluations/pdf/archive/fp7-evidence-base/experts_analysis/c.%20fotakis_-_research_infrastructure.pdf

a. the optimal performance and use of existing RIs, covering all fields of science in a bottom-up approach and,
b. the development of new RIs of pan-European interest through a strategic, top down approach, based on the ESFRI procedures.

Accordingly, several new funding instruments were introduced to optimise the use of existing RIs and to support the development of new RIs, to ensure that the European scientific community in all disciplines were able to stay at the 'forefront of the advancement of research, and able to help industry to strengthen its base of knowledge and its technological know-how'[6]. The INFRA calls included:

- support to existing national infrastructures that provide open access (integration, more efficient use, synergies via inter-related topics),
- support to integrate existing research capacities into a transnational access programme and joint research and networking programme,
- support to new Research Infrastructures (new concepts, support to construction & implementation) through Design Studies (DS) and by undertaking Preparatory Phase (PP) activities. The Preparatory Phase included, in a few cases, a second stage:
  Stage 1. supported the Preparatory Phase to enable the finalisation of financial, management and legal plans of the RI,
  Stage 2. supported the actual Implementation Phase of the RI in terms of construction and putting the legal, management and financial plans into practice,
- support to Policy development and Programme implementation (in the context of ERA, namely follow-up of ESFRI with Roadmaps and European legal framework ERIC for their management)[7].

For the Preparatory Phase support, only projects that were listed on the 2006 ESFRI Roadmap and later updates, were eligible to apply for funding. During this Preparatory Phase the European Commission was able to act as a facilitator, in particular with respect to the financial engineering needed for the Construction Phase. The role of the EU as a facilitator helped to ensure that lessons could be shared between the supported RIs as they explored legal, governance and financial models. Indeed, the lessons learned during the implementation of the FP7 Preparatory Phase projects have been shared widely and taken forward into the design of H2020 to increase the speed and efficiency for RIs as they move through their Preparatory Phases.

[6] Interim Evaluation of the European Research Infrastructures including e-Infrastructures in Horizon 2020.
doi: 10.2777/63168

https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/ri_interim_evaluation_expert_report_112017.pdf

[7] List taken from https://ec.europa.eu/research/evaluations/pdf/archive/fp7-ex-post_evaluation/capacities_final.pdf

During FP7, a new instrument was introduced to support the 'monitoring and further development of a European policy for Research Infrastructures, including international cooperation, needs for the development of specific actions, such as impact studies, surveys, development of a catalogue of research services or conferences'[8]. These new calls (INFRA-2009-3.1 and INFRA-2009-3.3) were intended to support the harmonisation of access and IPR related policies from across the ERA to make access and use of RIs more straightforward and to ensure that the range of services and support offered by RIs became more visible to potential end users.

Horizon 2020

The latest EU Framework Programme for Research and Innovation, Horizon 2020 (H2020) began in 2014 and runs through 2020. The total budget under H2020 allocated to support RIs was EUR 2.48 billion[9], significantly more than the total allocated to RIs under FP7. In H2020, RIs were included under the pillar of Excellent Science. H2020 aimed to optimise "the use of the national facilities by integrating them into networks and opening their doors to all European researchers"[10]. This confirmed that the concept of trans-national access was still a core feature of RI related investment. While scientific excellence has been at the heart of the H2020 RI funding instruments, RI initiatives are expected to have significant impact leading to a wide variety of scientific, economic, and social benefits for Europe and internationally[11]. To this end specific calls were introduced to support partnerships between relevant policy makers and funding bodies and to foster international cooperation. The aim was to increase the innovation potential of RIs, to increase RI use by industry and to increase the capacities of RI managers and staff through training or exchanges[12]. These calls were introduced to address recommendations made in the 2012 ERA Communication and in the FP7 interim evaluation report[13].

[8] 2007 Work Programme: Capacities Part 1. Research Infrastructures
https://ec.europa.eu/research/participants/portal/doc/call/fp7/fp7-infrastructures-2009-1/16036-n_wp_200901_en.pdf

[9] Developing the European infrastructures for 2020 and beyond
https://ec.europa.eu/programmes/horizon2020/en/area/research-infrastructures

[10] Developing the European infrastructures for 2020 and beyond
https://ec.europa.eu/programmes/horizon2020/en/area/research-infrastructures

[11] Interim Evaluation of the European Research Infrastructures including e-Infrastructures in Horizon 2020.
doi: 10.2777/63168 https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/ri_interim_evaluation_expert_report_112017.pdf

[12] Interim Evaluation of the European Research Infrastructures including e-Infrastructures in Horizon 2020.
doi: 10.2777/63168 https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/ri_interim_evaluation_expert_report_112017.pdf

[13] FP7 Interim Evaluation: Analyses of FP7 supported Research Infrastructures initiatives in the context of the European Research Area
https://ec.europa.eu/research/evaluations/pdf/archive/fp7-evidence-base/experts_analysis/c.%20fotakis_-_research_infrastructure.pdf

Evolution of instruments in H2020

To deliver the broad aims of RI support in H2020, specific funding calls were introduced, including:

- development [and long-term sustainability] of new world-class/pan-European Research Infrastructures (INFRADEV),
- integration and openness of Research Infrastructures of European interest (INFRAIA),
- development of e-Infrastructures (EINFRA),
- support to innovation, human resources, policy and international cooperation (INFRASUPP),
- establishment of thematic Clusters to foster the cooperation between RIs.

As noted in the introduction, the HLEG was tasked to assess the effectiveness of the Framework Programme funding instruments, in particular the Preparatory Phase funding for RIs in early phases of their lifecycle, via the individual support for fostering their implementation and enhancing their sustainability. Accordingly, we have focused mainly on assessing the INFRADEV and INFRAIA instruments. Over the course of the H2020 Research Infrastructures Work Programmes, the text provided for the specific calls has evolved to ensure that EU funding leads to better physical and virtual access to RIs, to increased open access to research outputs generated by RIs and to improve the potential for RIs achieving longer term sustainability. In some cases, the call topics themselves were renamed to reflect the changes, as was the case with the addition of 'long-term sustainability' to the INFRADEV call from 2015-2016 onward. Below, we provide a summary of the main call types for INFRADEV and INFRAIA and explore how the calls have evolved over the H2020 WPs. The evolution of specific H2020 RI funding instruments is described briefly below and presented in more detail in the tables in Annex 3.

INFRADEV

The aim of the INFRADEV calls has been to facilitate and support the implementation, long-term sustainability and efficient operation of the Research Infrastructures identified by ESFRI as well as other world-class Research Infrastructures, which will help Europe respond to grand challenges in science, industry and society. In addition, the next generation of new Research Infrastructures could be identified through Design Studies. Thus, INFRADEV calls were intended to support:

- Design Studies,
- Preparatory Phase of ESFRI projects,
- Individual Implementation and Operation of ESFRI projects,
- Implementation and Operation of cross-cutting services and solutions for clusters of ESFRI and other relevant Research Infrastructure initiatives.

The call texts for Design Studies (see Table 1 in Annex 3) evolved over the three H2020 Work Programmes. The call text in 2016 was amended to specifically address the notion that governance structures for RIs should be international in scope. The 2018 call text was amended to include reference to data curation and preservation, making specific reference to the FAIR principles[14]. The 2018 call text also made specific reference to the fact that proposals should make clear how they wouldl begin to address long-term sustainability. By requiring proposals to address sustainability, the EU reinforced the notion that planning for LTS cannot start too early in the RI lifecycle.

Based on a review of the Preparatory Phase call texts (Table 2 in Annex 3), it is clear that funding instruments have evolved to ensure that EU support is better aligned with the status of the ESFRI Roadmap and to reflect the findings of the various maturity assessments of ESFRI projects undertaken in recent years. The calls in WP 2016-2017 were updated to state that proposals should include legal and financial agreements with MS as key activities with related deliverables for each that are finalised before the end of the project (e.g. signing MoUs). In addition, the 2016-2017 call provided a list of detailed activities that could be included in Preparatory Phase proposals. Introducing a standard set of activities helped to ensure that those projects that received Preparatory Phase funding could focus their efforts effectively and that progress could be more easily tracked through the early stages of the RI lifecycle. In WP 2018-2020, the call text for Preparatory Phase funding stated that proposals should include an analysis of the societal and economic benefits of the infrastructure and that a cost-benefit analysis should also be carried out. These expectations reflect the increased emphasis being placed by the EU on ensuring the longer term sustainability and impact of RIs. From WP 2016-2017 onwards, proposals have been asked to address any synergies or complementarities with previous or current projects. This was an important addition and reflected the fact that the EC is keen to avoid repetition and double funding in its investments by improving cooperation and to encouraging clustering around areas of common activity.

As mentioned earlier, while H2020 has been first and foremost about scientific excellence, there were clear expectations outlined in the Work Programme that the RIs should deliver a broader range of impacts for society. Accordingly, the call text for Individual implementation and operation of ESFRI projects also made clear that the RIs should be providing a range of outreach, training and innovation activities to make their services and support visible to a wide range of potential end-users including the general public.

[14] The FAIR Guiding Principles for scientific data management and stewardship

https://www.nature.com/articles/sdata201618

As such, the call text asked proposals to make clear any synergies or complementarities with previous or ongoing EU projects. From the call text, one can see that there has been an increasing emphasis on involving industry in H2020, both as partners and end-users of the RIs, and on exploiting the innovation potential of RIs.

In 2019 a dedicated call to a single RI (ELI) was made to accelerate the implementation and operation of this specific RI. It was the first example of a single-target, ad-hoc approach. Its a-posteriori effectiveness will provide valuable evidence for the EU as to whether a more tailored approach for supporting individual RIs might represent a valuable option in Horizon Europe.
In 2016 and 2018 the EU decided to set up an ad-hoc 'Support to Early Phase of Research Infrastructures' to help those projects that had failed to enter the ESFRI Roadmap, but were nevertheless signalled in the Roadmap Landscape Analysis as 'Emerging Projects' or 'Projects with a High Potential', to achieve the maturity level expected for submission to the next ESFRI Roadmap update. A short-track (<1.5 years) or long-track (3 years) option of 'Early Phase' grants was made available in 2016 to the 'Emerging Projects' giving them an option to choose a quick re-submission to the 2018 Roadmap update or a longer refinement aimed at an update in 2020 (now planned for 2021).

H2020 included two calls targeting clusters of ESFRI projects and other world class Research Infrastructures. The INFRADEV topic aimed to support the coordination and exploitation of synergies between the largest possible number of ESFRI projects and other Research Infrastructure initiatives in a thematic area. To that end, proposals were asked to address interoperability of services and common solutions. The INFRAEOSC topic aimed to ensure the connection of the Research Infrastructures listed on the ESFRI Roadmap to the European Open Science Cloud through support for clustering ESFRI projects and landmarks according to large thematic domains (see Table 4 in Annex 3). These calls continue to support integrating activities of mature RIs with the intention of optimising the development and implementation of shared good practice, development/ adoption of standards and avoidance of duplicated effort.

We note that Research Infrastructures entering the ESFRI Roadmap are treated on an equal footing as far as INFRADEV support for Design Studies (DS), Preparatory Phase (PP) and individual support for implementation are concerned, despite them being very diverse in structure and overall cost. This results, at one extreme, in PP and individual support grants being of moderate financial impact for the very expensive single-sited large scale infrastructures (telescopes, particle accelerators, etc.), while at the other, the support provided being a significant proportion of the declared preparation costs for some distributed RIs.

This approach has not helped some distributed RIs that very early on have developed significant dependence on EU funding, to become independent. In such situations there is no perceived urge or need for the MS and AC owners of the RI to set up a sustainability plan, which later results in significant difficulties when approaching the end of EU support.

INFRAINNOV

A new instrument was introduced to support innovation (INFRAINNOV: Fostering co-innovation for future detection and imaging technologies) in the 2016-2017 and 2018-2020 work programmes. While it is still too early to draw concrete conclusions about the effectiveness of this instrument, to date successful engagement with industry has been somewhat patchy among the various RIs. While the call text encouraged close cooperation with industry, there could be value in exploring the benefits of making industry partnerships mandatory in future calls of this type.

INFRAIA

The INFRAIA instrument aimed to "bring together, integrate on European scale and open up key national and regional Research Infrastructures to all European researchers, from both academia and industry, ensuring their optimal use and joint development"[15]. INFRAIA supported this aim through Integrating Activities which mobilise key Research Infrastructures and other stakeholders in a given field. The Work Programme documents state that Integrating Activities should, whenever appropriate, give due attention to any related initiatives internationally (i.e. outside the EU) and foster the adoption and use of global standards, reflecting the growing recognition of the importance of internationalisation for RI services. As a condition of funding, all projects funded under INFRAIA had to include all of the following Integrating Activities:

- Networking Activities to foster a culture of co-operation between Research Infrastructures, scientific communities, industries and other stakeholders as appropriate, and to help develop a more efficient and attractive European Research Area;
- Transnational Access or virtual access activities to support scientific communities in their access to the identified key Research Infrastructures;
- Joint Research Activities to improve, in quality and/or quantity, the integrated services provided at European level by the infrastructures.

Under the INFRAIA instrument, there were two strands of funding, one specifically to foster Innovation Actions among Advanced Communities (AC) and another targeted towards enabling Integrating Activities for Starting Communities (SC). The inclusion of a dedicated topic, open only to Starting Communities aimed to foster areas of emerging integration between RIs.

[15] H2020 Work Programme 2014-2015. European Research Infrastructures (including e-Infrastructures)

A review of the INFRAIA call texts (see Table 5 in Annex 3) shows that over H2020 there has been an increasing emphasis on exploiting synergies with other RIs in the European landscape. By the 2018-2020 call, the text had been updated to stress that complementarities and coherence should be made clear in proposals to avoid duplication of effort. The call texts progressively focused on sustainability in the H2020 Work Programmes. In the 2016-2017 Work Programme, the call text stated that proposals should reflect on sustainability. This was carried over into the 2018-2020 call, however the call also stated that indicators should be provided to help assess progress towards project objectives including sustainability.

The H2020 Work Programme placed an emphasis on data access which was made clear through the introduction of the Open Research Data Pilot (ORDP). Expectations relating to data curation, preservation and access were provided in the 2014-2015 call text. By the 2016-2017 call, the text had been amended to state that even those projects opting out of the ORDP should define a data management plan demonstrating that the EU sees this as part of good research practice. In the 2018-2020 call text, a new reference has been provided to the recently developed 'European Charter for Access to Research Infrastructures'[16], which includes high-level guidance on research data management and access to data. A Pilot call has been issued in 2020 to cover three areas, astronomy, environment and nanoscience, to explore further evolution of INFRAIA with emphasis on transnational access.

[16] European Charter for Access to Research Infrastructures, 2016
https://ec.europa.eu/research/infrastructures/pdf/2016_charterforaccessto-ris.pdf

OBJECTIVE1: THE EFFECTIVENESS OF THE RESEARCH INFRASTRUCTURE FUNDING INSTRUMENTS

Methodology

The introduction and background above set the scene for the work of the HLEG aimed at assessing the effectiveness of the Framework Programme funding instruments, in particular the Preparatory Phase funding for RIs in early phases of their lifecycle.

LIFECYCLE APPROACH

The ESFRI Roadmap defines a number of lifecycle stages starting with Concept Development and running through Design, Preparation, Implementation and Operation before reaching a final Termination Phase[17]. Since 2014, ESFRI has refined a methodology for the evaluation of new projects and for the monitoring of their progress through their lifecycle towards implementation that has also impacted national practices as reflected in many national roadmaps. At international level the lifecycle approach has been adopted as a guide to analyse the Global Research Infrastructures (GRI) by the Group of Senior Officials (GSO) of G8+5, as described in the reports to G7-Science ministers in 2015 (Berlin)[18] and 2017 (Torino)[19].

[17] ESFRI Roadmap 2018, September 2018
http://roadmap2018.esfri.eu/

[18] Group of Senior Officials on Global Research Infrastructures – Progress Report 2015. Meeting of the G7 Science Ministers, 8-9 October 2015
https://ec.europa.eu/info/sites/info/files/research_and_innovation/gso_progress_report_2015_final.pdf

[19] Group of Senior Officials on Global Research Infrastructures – Progress Report 2017. Meeting of the G7 Science Ministers, 27-28 September 2017

https://ec.europa.eu/info/sites/info/files/research_and_innovation/gso_progress_report_2017.pdf

IMPLEMENTATION READINESS LEVELS

In light of the above, we decided to shape our analysis according to a similar lifecycle approach. The adopted methodology is consistent with proposals made by the Assessment Expert Group in 2013 and other national practices but develops a novel reference grid for assessing the progression between the lifecycle stages (or phases).

We have developed a set of Readiness Levels (RLs) to capture the main features and milestones of the implementation of a RI, i.e. the stages of the lifecycle in a more practical and measurable way. These Readiness Levels are analogous to Technology Readiness Levels, which are commonly used to provide a snapshot of a project's technological development. In this case, the RLs are defined to provide a snapshot of an RI's stage of development along its lifecycle.

The following table provides a reference grid for the Research Infrastructures 'Readiness Levels' that match the lifecycle stages of an RI.

Table 1. Readiness Level Reference Grid

RL	LIFECYCLE AND RL DESCRIPTION
	Concept Development, Design
RL1	Design Study – Conceptual Design Report – Initial agreement with at least 3 MS/AC; readiness to apply to ESFRI Roadmap
	Preparation[20]
RL2	Technical Design Study – advanced RI architecture, siting option evaluation and solutions - Cost Book, Data Management Plan
RL3	Advanced Financial Plan and minimum consortium plan – in-kind contributions estimate and policy; construction and operation cost analysis and relative discounted cash flow needs[21] for both construction and early operations; 'business plan' for the consortium.

[20] The activities to reach RL2 and RL3 may take place concurrently and may each have a different emphasis and duration depending on the specific nature of the RI.

[21] Guidelines on cost estimation of Research Infrastructures, StR-ESFRI Study, June 2019 https://www.esfri.eu/sites/default/files/StR-ESFRI2_STUDY_RIs_COST_ESTIMATION.pdf

	Implementation and Construction
RL4	Advanced legal setup, ERIC, AISBL or other. Stable minimum Consortium with 5-10 years financial commitment. European Investment Bank loan study, Structural Funds eligibility and suitability analysis with respect to financial/ business plan.
	Operation
RL5	Established RI, construction completed, operational budget in place, ESFRI-Landmark status or other (EIROforum etc.). Delivery of Science results, Open Access to Users, Science Services and Services for Innovation, Open Data facilities and basic FAIR Services, continuous upgrade.
	Advanced Science Services, FAIR Data and Data Services to support interoperability, progressing towards EOSC readiness, Clustered RIs, Synergy with other RIs and Integration of Access, continuous upgrade.
	Termination
RL6	Termination Phase, end of scope and evaluation of site conversion, or establishment of a decommissioning plan leading to dismantling, or disruptive reorientation of assets.

Reaching RL1: The initial formulation of a RI concept has very variable dynamics and often develops out of collaborative scientific research or networking or is nursed in the execution of Integrating Actions contracts that imply a large Transnational Access effort. A feasibility study is carried out during the conceptual phase leading to a Conceptual Design Report (CDR) usually funded institutionally or based on international collaboration, or sometimes carried out as a Design Phase (DS) in the FP. Design Studies stimulate bottom-up emergence of novel solutions for RIs and the production of formalised CDRs that describes the building blocks of the RI idea and project and sketches a first evidence-based analysis of cost and effort rquired. Projects that have produced a CDR (not necessarily through a Framework Programme supported DS) are at the readiness level required to be eligible to submit a proposal to the ESFRI Roadmap, provided a minimum of three Governments of Members States and Associate Countries express their formal political support.

RL2 and **RL3** correspond to the Preparation Phase of the RI lifecycle. A key support measure here is the FP Preparatory Phase (PP) grant, often followed or accompanied by other measures reserved for ESFRI Projects. The PP grants (typically EUR 1-5 million for 4 years) are meant to support the process of defining the key elements if the RI, from technical design to consortium construction and sustainability plan, in terms of both human and financial resources. The distinction between RL2 and RL3 is dependent on the specific nature of the RI. For example, a large single site, capital intensive RI may need a relatively long technical Preparatory Phase activity to reach RL2 that may or may not take place concurrently with the development of the financial and consortium planning needed to reach RL3, while in the preparation for a distributed RI based on existing technical or data resources, the emphasis may be on the financial and consortium planning with a much shorter technical design phase.

According to ESFRI the 10-year term should be largely sufficient for the Projects to reach the Implementation Phase (maturity) implying that:

- the Preparation is completed by the timely achievement of a full Technical Design Report (TDR) and a detailed Cost Book (CB) for the Construction Phase of the RI (major construction of a novel plant, construction/organisation of the headquarters of a distributed infrastructure, construction/organisation of national nodes),
- a financial and human-resource plans are drafted and validated by the partners,
- an established a sustainable legal vehicle to deliver and run the RI. This may be an ERIC or other treaty/consortium-agreement involving at least three MS/AC with, at least, a medium-term agreement to complete the Construction Phase and to start and carry-on the Operation Phase and the continuous upgrade of the science services to users.

These issues are typically addressed in specific work-packages within a general Preparatory Phase grant.

RL4 is the actual Construction Phase is of variable duration depending on the typology of the RI and the legal and financial implications. Although explicit support towards construction is not included in the FP measures, **collaborative grants** to develop technologies, in many cases, represent a real contribution to the Construction Phase, the effectiveness of which should also be assessed.

RL5 and **RL6** is the start of the mature stage of a RI and is characterised by advanced construction or start the delivery of scientific services to the user community for RL5 and advanced science services, FAIR data and data services for **RL6**. In line with the EU objective of consolidating the landscape of European RIs and highlighting their role in Horizon Europe Missions, RIs at RL5 and RL6 will become active in clustering activities to address shared challenges. The Landscape Analysis update of ESFRI has indicated the importance of interfaces between RIs both in the same domain of science as well as between disciplines. A vision of a well-connected system of RIs has been proposed in the ESFRI Roadmap 2018, and 'clustering' is one of the steps toward this process.

Definition of Effectiveness

As our task was to assess the effectiveness of the Framework Programme funding instruments, the group looked into the definition of 'effectiveness'.

The EC Better Regulation Toolbox[22] states that: "Effectiveness analysis considers how successful EU action has been in achieving or progressing towards its objectives. The evaluation should form an opinion on the progress made to date and the role of the EU action in delivering the observed changes. If the objectives have not been achieved, or things are not on track, an assessment should be made of the extent to which progress has fallen short of the target and what factors have influenced *why* something hasn't been successful or *why* it has not yet been achieved. To this end, effectiveness analysis should seek to identify the factors driving or hindering progress and how they are linked (or not) to the EU intervention".

Bearing this definition in mind, the group adopted a pragmatic approach and considered that the effectiveness of an EU action could be considered to be the extent to which it helped RIs to move between the Readiness Levels (RLs). As described in the table and text above, the RLs provide a breakdown of specific milestones that an RI should achieve for successful implementation and long-term sustainability. The rationale of our analysis of the effectiveness of the FP support measures, delivered over roughly the last 15 years, is therefore based on their *a-posteriori* effective contribution to RIs reaching these milestones.

Sources Used for the Analysis

The EC made available to the group many of the document files for the FP7 and H2020 calls that featured Research Infrastructure support instruments, the reports (interim and final) of the awarded grants including Design Study (DS), Preparatory Phase (PP), Individual Implementation Support (INFRADEV III), Research and Innovation Actions (RIA) and Support Actions (SA). Also, the final monitoring and Landmark evaluation files of the ESFRI Strategy Working Groups (SWGs) and Implementation Group (IG) for the 2016 and 2018 Roadmaps were made available, with the agreement of ESFRI and the RIs concerned. Finally, it was possible to access the ERIC Phase-1 evaluation outcomes.

[22] Better regulation "Toolbox" – European Commission

https://ec.europa.eu/info/sites/info/files/better-regulation-toolbox_2.pdf

We noted the following however:

- that EC external reviews are designed to focus on contractual implementation, deliverables, milestones and grant objectives which can mean that the effective progress achieved, or bottlenecks encountered by the RI at the end of an EC grant do not clearly emerge from the project documents;
- the evaluation of proposals from an RI does not take into account the previous history or progress of that RI or the results of earlier funding (or at least this information is not made available in reviews or assessments),
- the repeated work package structures observed in some RI projects could indicate that there has been insufficient progress on addressing the issues in previous funded projects, but could also be the result of a perceived 'obligation' for proposals to cover all aspects of the RI development listed in calls, regardless of their previous achievements,
- the EC lacks a personalised track-record of measures exploited by a given RI, and of its successes (a structured dossier). This makes it difficult in some cases to reconstruct the overall effort dedicated to a given RI initiative.

We therefore felt that we needed to gather additional and more uniform information. This was done by exploring, with the help of CORDIS, the past record of FP6 and earlier FPs as well as other RI measures and the RI websites which sometimes report the history of EC grants and contracts. The full series of ESFRI Roadmaps (2006-2018) and Landscape Analyses therein were also consulted.

The group worked on the available documents, to form an initial assessment of the effectiveness of EC funding instruments in supporting the structuring of a science community, refining the concept of a RI and moving through the steps of establishing the RI lifecycle.

Effectiveness of the EU instruments in moving the RI forward to implementation and sustainability

As discussed above, in performing our analysis, we examined how effective EU funding instruments have been in enabling the set of 49 RIs defined earlier to move between RLs. The history of ESFRI submission and monitoring, achievement of Landmark status as well as the realisation of a stable international consortium (e.g. ERIC), were considered indicators of progress. Some common issues emerged and these are examined in the rest of this section.

USE OF FUNDING

Examining our assessments of the 49 RIs under study, we found that the median number of grants received by each RI under FP7 and H2020 was four with an average of 4.8. The median number of grants to move from **RL1** to **RL4** was two with a range from 1 to 4. In terms of cost, the average funding received during the preparation and implementation stages was EUR 10.2 million with a range from EUR 1.5 million to 41.2 million. Finally, we found that it took RIs between 2 and 12 years to move from RL1 to RL4 with the average being 8.4 years.

Looking at the declared figures of estimated costs from the ESFRI 2018 Roadmap it was noticeable that many RIs either did not provide them or had inconsistent declarations with respect to previous Roadmaps. We believe that the cost data should be much more reliable, and mandatory for RIs on the Roadmap, in order to enable a robust analysis.

Having a thorough cost analysis is an obvious key requirement for sustainability as well as for calibrating the effectiveness of the EU measures during the Design and Preparation Phase. ESFRI has initiated an analysis of methods for effective and transparent cost analysis with the help of economic experts. The proposed cost estimation model includes all the material and other costs, which are functionally connected to the completion of the RI mission. It introduces the discounted cash flow method to harmonise the system of accounts and prices to be applied to the entire lifecycle of the RI. Some of the main findings are part of the new guide to the Roadmap 2021 both for new projects and for monitoring purposes.

Despite the fact that the currently available data are often incomplete or inconsistent, some patterns clearly emerged:

- the Physical Science & Engineering (PSE) Landmarks received, on average EUR 12 million in direct funding during the 10 years as ESFRI projects representing a fraction of the cost of design and preparation;
- the Social & Cultural Innovation (SCI) Landmarks, also received an average of EUR 12 million in direct funding during the same period. While for some RIs this included early operations, this level of support represented a substantial contribution against the full cost of these RIs;
- all RIs of the other research domains fall in between and the EC direct funding covered a significant fraction of the full declared costs of design and preparation.

If one considers the envelope of support from EC grants that are not uniquely allocated to an individual RI but of which the RI is one of the beneficiaries, we observe that an average of EUR 35 million is equally available to all RIs, with the Health & Food (H&F)

RIs reaching EUR 40 millions and PSE reaching EUR 32 million. We observe no correlation with actual cost of the RIs or need for national funds.

This point is of relevance from the perspective of the national funders in that it creates a large asymmetry between the different RI domains which is reflected in cases of RIs being less incentivised to develop LTS plans.

In order to understand better how RIs actually used EU funds, in Table 2 we have mapped the activities that are typically seen during a RI's progress through the lifecycle described earlier and mentioned in the EC funding instruments, against those funding instruments.

Table 2. Funding instruments covering the cost of concept development, preparation and implementation of RIs.

	Integrat. Actions	Design Studies	Ad hoc Support	Prep. Phase	Individ. Support	Cluster
Community building	X					
Concept development – CDR		X				
Project development –TDR		X	X	X	X	
Community consolidation around RI project	X	X		X		
Submission to ESFRI	X	X	X			
Cost book, HR management, governance				X	X	
Legal set-up, temporary / stable				X	X	
Siting / financial set-u to reach coverage of 80% cost-book estimates				X	X	

Financial / business plan: in-kind contributions / coverage of operational costs				X	X	
Operation stage / running costs / users access / transnational access	X					
e-need costs related to DPM, data services, HPC, EOSC				X	X	X
Clustering						X
Cross-domain integration						X
Merging	X					X
Major upgrades / disruptive upgrades / reorientation				X	X	
Internationalisation / GSO-GRI						X
Termination / decommissioning						

Table 2 shows that several activities are covered by more than one funding instrument. Activities such as project development can be carried out under up to 4 instruments, while community consolidation and submission to ESFRI appear under at least 3 instruments. Careful attention must be paid to avoid duplication of funding for the same activities in different grants. Duplication would undermine the effectiveness of EU funds and would not lead to faster implementation of the RI.

As noted above the Preparation Phase can be lengthy with the average time taken to move from **RL1** to **RL4** exceeding 8 years. With, in some cases, RIs duplicating activities across grants simply to ensure that all aspects of the call text are addressed for a favourable review whether they are needed or not.

It seems that targeted funding, focused on RIs undertaking a subset of all possible call-related activities may be more effective. In this way, RIs could tailor their project activities to optimise their likelihood of progressing between readiness levels. By tailoring the funding instrument to allow RIs to address a subset of specific activities, we believe that the time needed to progress between RL1 and RL4 would be reduced as RI efforts would be focused where they are most needed rather than dispersed across less urgent activities. A 'personalised' approach should be developed to ensure maximum European added value for all RI types, while avoiding the creation of long-term dependence on EC funds.

We note however that there are a number of distributed RIs where the EU funding has primarily been used to bring together the distributed elements in a way that probably would not have been possible without such EU funding, making the use of the funding an effective way to achieve sustainability.

PROGRESS THROUGH THE READINESS LEVELS

There is evidence that quite often the outcome of the Preparatory Phase grant is not sufficient for the RI to reach RL4 on one or more of the key aspects of implementation. Extra time is generally needed by the RI, while support may not be adequately, or not available at all, in a timely manner at national level. Projects have described as 'the valley of death' the years between the end of PP and the end of the 10-year residency on the ESFRI Roadmap. To cope with this difficulty, mitigation actions have been implemented by the EU with a series of ad-hoc measures that, one way or the other, have directly supported the implementation of several RIs. These have included in some cases a second, shorter PP (PP2) or an individual support (INFRADEV) project to allow the RI to address some specific bottlenecks hindering its implementation.

Additionally, there are some compulsory elements in all grants (such as human resource management, IPR issues, data management plan) that seem to be listed as new tasks even when they have already been successfully addressed in a previous grant, for the same organisation.

We believe that a ***staged approach*** *for RIs appears to be a much preferable solution, in line with what was previously recommended by the AEG in 2013 and which we have formulated above according to our lifecycle approach and RL-achievement rationale.*

The very structure of the FP proposals and grants enhances this 'inefficiency' as far as RIs moving up the RL ladder is concerned. For example, each FP project has independent referees leading to lack of consistent oversight across the lifecycle. Adoption of a RL approach would allow reviewers to have a framework for understanding the status and scope of the given project, which would not be evaluated as 'stand-alone' activity but as a stage of a process with a starting RL and the challenges to reach the next RL. The procedures for external reviews of EU projects are grant-based, and for the RI programme they should incorporate tracking of previous support and outputs. Otherwise it is not possible for reviewers to assess the progress made by the RI up the RL Ladder.

We note that staging of support is based on the achievement of results (RLs), requires the acceptance of assessments by a recognised authority. This is a delicate issue that requires consensus and trust in the adopted instrument. The 'authority' needs to be recognised by MS, as the achievement of a Readiness Level often triggers not only new EU funding but also additional MS funding (more so as the RL scales up).

A panel of independent experts should be set-up by EC in collaboration with ESFRI, with fixed term engagements, a consistent methodology, and rotation mechanisms that balance continuity and renewal. The panel would evaluate the successful achievement of an RL at the end of each FP-funded grant or contract, as well as on request by the MSs and ACs that are financing the development of the RI. The panel should make use of all established indicators but should also independently analyse the specific features of the RI, its consolidated status in the lifecycle, as well as the evolution of the Landscape, in order to help in optimising the next steps.

MONITORING RI PROGRESS

The current status of a RI must be updated periodically throughout the ten-years of the implementation process and later during the multi-decade Operation Phase. These control actions (monitoring, updating) of RIs are intrinsically different from the standard assessment of a research project that typically has short/medium term goals and financial needs.

Although ESFRI has developed and carries out assessments and reviews linked to project lifecycles, the results of these assessments and reviews are not designed to be used by the EC in assessing and awarding grants and agreeing deliverables and milestones. It is recommended that the EC works with ESFRI to ensure that the results of ESFRI's evaluations, assessments, monitoring and periodic reviews can be shared with the EC and used as reference information when assessing projects and making funding decisions. Equally it would seem logical for ESFRI to consider the results of EC funding in making its periodic monitoring and update of RIs on the roadmap. With this in mind the EC and ESFRI should consider using a shared assessment methodology rather than both looking at maturity and sustainability using different and non-comparable means. It is also important that the RIs themselves have a consistent way of reporting on their progress and sustainability.

A further issue that became evident while preparing this report and analysing the progress of the Research Infrastructures is that even though the infrastructures are evaluated by different committees and different experts, including ESFRI groups, the recommendations are not always addressed by the RIs when they are applying for a subsequent EC grant. These recommendations are given with a purpose of strengthening RIs. Their follow-up should be required if we believe that the objective is to move the RI forward in its development.

To avoid such situations, each stage of the RI development (and EC funding) logically should build on what has already been achieved. In order to be able to assess the implementation of the objectives, the independent authority described above would need to assess whether the RI has achieved the target RL and is therefore eligible to apply for the next stage funding.

The fact that a RI is on the ESFRI roadmap should not lead to an automatic expectation of financial support. The RI should fulfil certain criteria and should show progress before applying for the next financing instrument.

In order to facilitate the recommended staged approach and targeted funding, a 'dossier' for each RI should be created by the EC, tracking its funding history and successful achievement of its own goals and timeline, as verified by institutional, national, EC, EC Experts, ESFRI, or other assessments. The RI-dossier should be the reference for all assessments and should be accessible, upon request, by national authorities or by the RI itself.

MEMBER STATE COMMITMENT

The major weakness in most RIs assessed was the inability/failure to reach strong, long-term financial commitment from the Member States participating in the RI. As such, securing financial commitments should be the major focus of the RI's Preparatory Phase activities. One option to promote the commitment of the MSs would be to provide EC funding subject to co-funding from MSs (in-cash rather than in-kind only).

The informal nature of the relationship between ESFRI, the Commission and Member States described earlier, while successful, does have consequences especially when it comes to the subject of Member State commitment to construction and operations funding.

Since 2014 a new infrastructure seeking to gain entry onto the current ESFRI roadmap is required to have political support from a minimum of three Member States or Associated Countries plus a financial commitment to contribute to the RI's preparation and Implementation Phases from the proposed Host State. Overall the level of financial commitment can be quite small and is often provided in-kind rather than in-cash. The EU on the other hand, essentially guarantees funding for the Preparatory Phase and offers funding opportunities for partial support of the Implementation Phase for all RI accepted onto the roadmap. The result is that many RIs are able to move through their Preparation and Implementation Phases without securing the (national) long-term financial commitment needed to reach maturity and enter sustainable operations.

It is suggested that in order to improve the prospects for sustainability, the EU should insist on Member State contributions to the funding of the Preparatory and Implementation Phases with a significant element of the Member State funding being provided as cash.

Furthermore, in order to encourage projects to work to increase financial commitment, it is recommended that the EU should insist on milestones linked to continued funding based on specific targets for increased financial and political commitment.

VISIBILITY OF THE OUTPUTS OF THE EU GRANTS

Dissemination of knowledge resulting from EU funded projects is crucial for the visibility of the effort that Europe puts into the development of research and innovation. In EU-funded projects it is done in particular via dedicated websites and other relevant media. However, it seems that in the case of the Research Infrastructure it is not so straightforward. The difficulty is that during their construction, infrastructures go through different phases of their lifecycle which can be financed by different EU instruments, corresponding to different EU funded projects. The partners are not always the same from one project to another, and even the coordinators can vary depending on the lifecycle phase (e.g. Design Study and Preparatory Phase can be coordinated by different partners from different countries). This can often lead to each project having its own website linked to a certain EU funding instrument.

While the same infrastructure can benefit from different EU funding instruments at different lifecycle stages, it is not always easy to see how different projects relate to the different stages of the lifecycle and indeed it is often the case that separate project websites are not well linked with either the RI or related projects. As another example, identifying the outputs of different projects carried out under different EC instruments can become quite confusing if the same aspects are carried out in parallel, using several parallel EC funding grants, direct or in a cluster. These situations can make it very difficult to identify the whole infrastructure in the multitude of the projects and websites, and the process of the infrastructure construction is not visible. To ensure the visibility of the Research Infrastructure funding, it would be helpful to reflect the whole process and the timeline on the same website of the infrastructure, which would help to show the evolution of the RI and how it relates to other RIs/projects.

To address these issues, we recommend that EU funded projects related to the set-up of a Research Infrastructure are encouraged to co-create the RI website instead of creating separate project websites. Separate websites involve more work and introduce the risk that the project work is seen as separate to RI maturity progression rather than part of a bigger picture for the RI.

Furthermore, RIs should be encouraged to provide historical timelines on their websites which should include acknowledgement of EU funding along with grant numbers and links to the CORDIS summary page and outputs.

INTEGRATING ACTIVITIES

While the Integrating Activities under FP7 and H2020 have been particularly valuable for many RIs and several of the current ESFRI Landmarks have benefitted by extending their networks through this support, a recent assessment report recommended that funding for IAs should place an emphasis on supporting starting communities and suggests that there could be value in setting a maximum time limit for supporting IAs for advanced communities[23].

[23] Interim Evaluation of the European Research Infrastructures including e-Infrastructures in Horizon 2020. doi: 10.2777/63168

https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/ri_interim_evaluation_expert_report_112017.pdf

"The share of funding between 'advanced communities' - groupings already to some extent established - and 'starting communities' is favouring the former and involves too often repeated or supplementary support and repackaging of established partnerships.

Advanced community support should focus on those proposals able to show a realistic likelihood of integrated European operation being maintained beyond the period of the award without further EU support. Overall, support for what is in essence the same consortium (or a subset of it) from H2020 RI or its predecessors should be limited to a maximum of 10 years".

IAs have been key to the development of RIs and RI services. Two types of IA beneficiaries have been addressed: those national RIs with international scope that could benefit from coordination of transnational user access, and those research laboratories that could start opening their extra capacity (beyond their own research needs) to TA, thereby developing good practice as providers of infrastructure services and integrating the technical development strategies with similar laboratories.

Some RIs, e.g. national synchrotron radiation laboratories, neutron scattering facilities, hadron physics facilities, astronomical observatories, have applied repeatedly to IAs as a useful contribution to transnational users. These RIs remain nevertheless frustrated at the lack of direct contribution to the operational costs result from the European and international openness of merit-based access. The available IAs budget however, cannot support these long-term IAs at a satisfactory level so that the Joint Research Activities and Networking Activities that were elements of the structuring scope of IAs, have been progressively sacrificed to concentrate the resources to the Transnational Access activity. Another class of beneficiaries of IAs have generated some efficient infrastructure services based on extra capacity of national and institutional resources not originally designed to operate as RIs. These IA-networks involve state-of-the-art laboratories that benefit from Joint Research activities and Networking Activities and offer a valued TA service to broad user communities.

Special attention should be paid to this type of IA-networks that operate high-quality and unique RI services, but that do not plan to evolve into an ERIC or other centrally coordinated RI. They rely on IAs, and therefore repeatedly apply to make their infrastructure services sustainable, but they do not see this action as a preliminary to actually becoming a formal RI. Consolidating these very useful infrastructure services, without forming a new RI, while introducing appropriate monitoring instruments, is a relevant option for the next Research Infrastructure Programme under HE.

The starting communities instrument is also important, as it may create new user services in new areas of research. These starting community proposals should nevertheless be very carefully evaluated. There has been some growing asymmetry in research funding between projects claiming to perform infrastructure services, that face little competition, and excellent science projects that suffer from extreme competition. This is a sensitive issue that has implications on the sustainability aspects of RI actions. It could be that pressure on Starting Communities IAs has grown as a consequence of the reduced funding opportunities for excellent collaborative research in Europe.

The time limit approach for supporting the integrating activities of advanced communities is worth exploring. However, it is also important to note that research is becoming increasingly interdisciplinary and even advanced communities will find themselves needing to broaden their networks to effectively address new challenges. In this respect, future calls could require that requested support (where appropriate) makes explicit how the proposed IA will facilitate increased effectiveness of the RI.

A Pilot RIA call for 2020 has been opened addressing three communities (astrophysics, environmental sciences, and nanoscience-nanotechnology), which may help in exploring novel configurations of consortia and service providers, with emphasis on TA.

Overall Integration Actions have beneficial effect for all types of communities, but the IA experience does not necessarily have to lead to the development of a solid RI concept that would be sustainable as an independent legal entity and nor should it. Some starting communities seek support for multiple integrating activities. We believe this is often due to a lack of funding alternatives for collaborative research that may push them to explore the RI option as a research funding instrument.

A way to consolidate the network-offering-TA operation for those IA that provide an important RI service, of high relevance for European research competitiveness, should be implemented. Stabilising successful IAs as Infrastructure Service Consortia, co-funded by the EU and MS-AC, could be an effective solution to several relevant research sectors. The continuing need for such consortia should be periodically monitored along with their quality/quantity of scientific and innovation productivity.

Essential services for the integration and competitiveness of European research can be ensured without creating new entities (RIs) in those cases when a well-coordinated consortium of independent institutions can operate them successfully. Special measures to ensure the sustainability of the services, and the adequate monitoring of the quality and persistence of the scientific community needs, should be designed as a way of optimising the landscape of RI services.

Proposed Support-Instruments for RI progress through the Readiness Levels: A new model for Horizon Europe

The lifecycle approach and the use of Implementation Readiness Levels described above have enabled us to assess a-posteriori the effectiveness of the FP instruments in supporting the development and implementation of the RIs. By analysing the progress of the RIs through the grid of Implementation Readiness Levels it turns out that most often the preparation for implementation, i.e. the transition from **RL1** to **RL4**, largely exceeds the duration and cost covered by a Preparatory Phase grant, so that either PP2 or INFRADEV-III grants must be awarded subsequently in order to reach RL4. In several cases we have seen a number of other grants being used by the RI in parallel, often addressing the same key activities associated with progress from RL1 to RL4, albeit under different titles. It appears that a potentially more effective support system could be developed in the future by adopting the Readiness Levels as goals of staged support-instruments.

We believe that an Implementation Readiness Level analysis, based on the lifecycle approach, can serve as an operational tool to design effective instruments of the Framework Programme to foster the implementation of the RIs. In essence our proposal is that funding instruments should be specifically defined to enable and accelerate the movement of an RI from one RL to the next. At each step an assessment has to take place (a checkpoint) to verify that the RI has achieved its goals and is eligible to apply for support to help it to move to the next stage.

All instruments are redefined in connection with the lifecycle approach and with reference to the Readiness Level grid. The Integrating Activities are proposed proposed as an alternative route to stabilising proven useful infrastructure services without the obligation of adopting a RI statute.

- The RI support grants/contracts are all connected to moving up the ladder from RL1 to RL4 that is the completion of the preparation. The checkpoints at the end of a grant should verify that the target RL has been reached. Successfully achieved of the target RL will enable the RI to apply to the next grant to reach the next higher RL. In case of failure the RI can complete its effort with its own means and apply for a verification on reaching the target RL when ready.
- Note that the transition from RL4 to RL5 is the Construction Phase that is not in the scope of EU support and it is expected therefore to be carried out by the RI consortium with its own resources.
- RL5 is the long-term state of operational RI (20-50 years) that should also be sustainable in order to realise the return on investment.
- Further RI support grants/contracts may support the RL5-RL6 evolution of an RI

towards integration and consolidation of the Landscape with interoperable services for the production of and access to scientific data. This RL5-RL6 evolution is one of the goals of HE, but it will be a choice of the RI to engage in this evolution and when.
- The sustainability plan of a RI should also identify resources to address the RL7 Termination Phase.

Below we outline the proposed funding instruments based on our observations of the effectiveness FP Instruments in supporting the set of RIs analysed. We then make a number of specific recommendations designed to underpin the operation of the new instruments.

INTEGRATING ACTIVITIES

Supporting the research communities and TA to existing access capacity
• The Integrating Activities (IA) are unique in creating the possibility for a thematic or interdisciplinary research community to organise around a TA programme that exploits existing national or institutional resources. • The IA communities may develop the concept of a highly integrated Research Infrastructure, through a distributed RI model, or the concept of an all-new RI pushing the frontier of capability in the domain, reaching the **RL1** or, alternatively, leading to the concept of stabilising a collaboration and TA-providing network. • The EU should continue to support Integration Actions in all possible implementations: becoming an RI (i.e. reaching **RL1**) should not be the only option, there should also be the option of a stable TA-providing network and consequent (partial) support. • The scientific merit of Integrating Activities of starting communities should be carefully assessed.
Checkpoint: self-assessment including assessment of the RI vs. network choice.

DESIGN OF A EUROPEAN RESEARCH INFRASTRUCTURE – RL1->RL2

This phase of lifecycle from **RL1** to **RL2** requires a technical design effort and a costing exercise that must be accomplished by the delivery to the stakeholders of a Technical Design Report and Cost Book adequate to demonstrate the uniqueness of the scope of the infrastructure, its adequate capacity, the quantification of the scientific, technology, human resource and territorial dimensions.

Supporting the Consolidation of RI Design and Demonstrating Uniqueness/ Capacity
• The Design Study instruments should focus on the move from RL1 to RL2. • The applicants should support clearly defined personnel effort for technical work including: prototyping activity and technological development, siting requirements (central laboratories, national hubs), siting discussions with stakeholders with analysis of options. • The final delivered report should be assessed as sufficient to engage the financial analysis by funders and final siting decisions. • The final delivered report should also indicate the resources and timeline for the follow-up work of prototyping and updating the TDR required for al construction decision.
Checkpoint: expert assessment (scientific, research organisations, scientific associations, business consultants) of the soundness of the technical choices and their feasibility of the TDR and Cost-Book.

PREPARATION OF A EUROPEAN RESEARCH INFRASTRUCTURE – RL2->RL3

This phase of the lifecycle from **RL2** to **RL3** requires a financial analysis, including the discounted cash-flow analysis, of the RI as described by the TDR and cost-book and the simultaneous definition of the minimum consortium that could produce adequate in-kind and cash contributions for construction and early operation of the RI.

Supporting the RI consolidation of RI Design to develop Financial and Organisational sustainability
• The Preparatory instruments should focus on the move from RL2 to RL3, supporting personnel effort and consultancy with financial advisors, business advisors and territorial developers as well as ministerial conferences for addressing Smart Specialisation opportunities and structural and investment fund options. • A timeline of cash-flow and an in-kind contribution management plan should be drafted and validated by financial advisory and/or ministerial authorities. • Description of the minimum viable consortium to carry on the RI project. Ministerial conferences to establish a consortium scheme and strategies to increase its membership in such a way to qualify for further implementation of the RI. • Establishment of a binding letter of intent / memorandum of understanding for carrying out the RI implementation and formalisation of consortium.
Checkpoint: expert assessment (financial, regional developers, DG REGIO where relevant, Ministries) of the soundness of the financial plan.

PREPARATION OF A EUROPEAN RESEARCH INFRASTRUCTURE – RL3->RL4

This phase of the lifecycle from **RL3** to **RL4** requires the achievement of a legal consortium capable of engaging in the construction of the RI and in its early operation. A minimum number of Partners (MS+AC) capable of engaging adequate resources (>80% of total construction cost as from RL3) for at least 5-10 years must join in a legal format. This could be an ERIC or other legal format capable of providing the warranties enabling the application for EIB loans or Structural Fund evaluations or other financial instruments.

Supporting the RI for finalising the Legal consortium and Construction Phase sustainability
• The Preparatory instruments should focus on the move from RL3 to RL4, supporting personnel effort and organisation of consortium conferences at ministerial level to promote the convergence to a format and schedule for establishing the consortium. • Advanced legal setup, ERIC, AISBL or other in place. European Investment Bank loan study, Structural Funds eligibility and suitability analysis with respect to financial/business plan. • Support the work of coordination and alignment of decision making and financial instruments by the Partners and the EU.
Checkpoint: official establishment of a legal entity, MS+AC formal engagement into ERIC or other legal instrument with a financial commitment of 5-10 years.

CONSTRUCTION OF A EUROPEAN RESEARCH INFRASTRUCTURE – RL4->RL5

This phase is not in the scope of EU support. It is expected to be carried out by the RI consortium with their own resources.

A **RL5** RI is operational, delivers science services, has a user programme and a data management plan in place and is compliant with the EOSC. It also has a regular upgrade programme to keep it at the forefront of competitor facilities.
Checkpoint: openness to users, established track-record of science and innovation.

INTEGRATION OF RESEARCH INFRASTRUCTURES – RL5->RL6

This phase of the lifecycle from **RL5** to **RL6** may be realised when the development of connections and interoperability with other RIs in the same domain, or sharing similar needs in terms e.g. of application of FAIR data principles, data management (storage, access), data analysis, are mature and strategically needed for the RI.

Supporting the RI for consolidating and integrating with other RIs to enhance interoperability
• The CLUSTER instruments should support joint efforts by several RIs to coordinate action and develop interfaces towards interoperability as data production and analysis facilities and as data repositories. • Actions towards facilitating interoperability and performance of interdisciplinary research. • Actions to foster inter-RI collaboration on common issues.
Checkpoint: expert assessment and other RI assessment of integration level. Compliance with FAIR data and FAIR data services as defined by the EOSC. Participation in the (future) EOSC.

As discussed in sections 3 and 4 the key points in this methodology lie in the effectiveness of the checkpoints that should be under the supervision of the described authority, and the creation of a personalised dossier containing evidence of all EC and other declared national funding exploited by the RI. This introduces an ex-post evaluation at each stage which results in a potentially very effective ongoing monitoring of the RI. The control of the grants should be performed both on the description of action to be performed and on the state of play of the RI through its lifecycle.

Recommendations to Support the Operation of the Proposed Instruments.

- The Preparation of a RI should be supported by a staged approach as far as the EU support is concerned. Staged support instruments may represent an administrative burden for the EC, but probably no more so that the current situation of the same project being involved in several parallel and serial grants.
- The EU Grant instruments should evolve to include contractual aspects that achieve two goals: to have the Member States or their Representing Institutes join as co-financers, and to have checks on the actual RI progress, rather than just demonstration of effort expended.
- Staged support instruments should require a final assessment of achievements of the RL (or RLs), which will enable the RI to apply for a new grant targeted at achieving the next RL.
- An assessing authority must be defined and established. Expert assessment based also on the collection of evidence from other monitoring exercises (ESFRI, national, stakeholders) could be a model.

- Staged support instruments should clearly identify which activities should be pursued by the RIs to advance to the next RL, independent of the type of RI. However, there should be scope for personalisation in terms of their duration and most appropriate level of financial support.
- Failing to reach the target RL at the end of a support-instrument should be a bar to applying to any support instrument in the next call.
- A second support instrument to reach the same RL can be applied for but not in continuity (similar to European Research Council rule).
- While each RL could be reached independently from EC support, future applications for support would require an expert assessment.

OBJECTIVE2: RESEARCH INFRASTRUCTURE PROGRESS TOWARDS IMPLEMENTATION AND LONG-TERM SUSTAINABILITY

To assess RI progress towards implementation and long-term sustainability, we have performed individual assessments as snapshots of the current implementation stage of 43 RIs, selected as described in the introduction to this report. In addition, five EIROforum sponsored RI developments were looked at as a group.

Methodology

We adopted the definition of Long-Term Sustainability as discussed by the EC Staff Working Document (EC SWD). In particular, the seven-step action plan for LTS identified in the EC SWD was used as a guide in requesting input from the RIs and in analysing their responses.

In performing individual assessments, members of the group analysed publicly available information, reports and documents provided by the European Commission as well as concise written contributions from the RIs, providing updates on their current stage of lifecycle, scientific goals and perceptions of bottlenecks to long-term sustainability and future prospects.

Details of the methods and goals of our work were presented at the ESFRI meetings in Brussels (June 2019) and La Palma (October 2019). In several cases a direct dialogue took place between the HLEG chair and the RI to provide further explanations clarifying the scope of this exercise and obtaining the requested information. The 43 RIs, for which individual assessments were completed, were given the opportunity to fact-check the draft reports.

To assess the RI progress towards implementation we applied the Readiness Levels defined in Part 1 of this report. This is a methodology created and applied for the first time by the HLEG, which is fully responsible for it.

In evaluating the future outlook of the RIs with respect to their long-term sustainability we were guided by a number of indicators that describe the seven elements of the EC-SWG Action Plan for a sustainable RI. These indicators are summarised in Table 3. They can be applied to the main part of the RI lifecycle (**RL3-RL5**) with, for example, policies or practices in development, in place or in operation depending on the RL of the RI. In broad terms, at **RL3** all the seven LTS elements should be present in the preparation plan of the RI, whilst at **RL4** each LTS element should be under construction with final policies put in place and by **RL5** all LTS elements should be implemented and operational.

In addition to providing individual recommendations for each we also performed an analysis of common characteristics and features of the RIs. Later in this report, the analysis is summarised by typology of RI, by homogenous thematic area, and by the steps in the lifecycle along with overall recommendations on future actions to promote full deployment and long-term sustainability of the RIs within the scope of Horizon Europe, EOSC and internationalisation measures.

Table 3. Indicators for Long-Term Sustainability used as background of HLEG analysis

	Ensuring scientific excellence	Attracting and training the managers, operators and users of tomorrow	Unlocking the innovation potential of RI	Measuring Socio-Economic Impact of RI	Exploiting better the data generated by RI	Framework conditions for effective governance and sustainable long-term funding for RI	Structuring the international outreach of RI
ToR BULLET POINTS	• Key Performance Indicators • Capacity to maintain leadership in terms of instrumentation and services in relation to scientific/ technical developments	• Catalogue of services • Service-driven approach	• Users' communities and outputs also in terms of innovation and TRLs	• Socio-Economic Impact		• Critical mass and added value of the RI (in comparison with a network) and prospection of new members • Complementarity of the activities of the RIs and possibilities for consolidation with overlapping/ related RIs	•Effectiveness of embedding international partners in the RI and of the cooperation with relevant international partners
RANGE OF POTENTIAL INDICATORS RL5: AVAILABLE AND FULLY OPERATIONAL RL4: UNDER CONSTRUCTION AND POLICIES IN PLACE RL3: PREPARED WITH AGREED POLICIES IN DEVELOPMENT	1. Access policies in line with EU Charter on Access to RIs (source: website) 2. Excellence-driven model of access regardless origin (source: Access Policy) 3. Training modules for users (source: visible on website) 4. KPIs developed and monitored as part of governance (source: Annual Report) 5. Recommended citation to acknowledge RI contribution (source: Access Policy)	1. Staff training including exchange programmes (source: Annual Report, RItrain project) 2. Transnational access to RI (source: website) 3. Disseminate opportunities for access and jobs (source: EURAXESS, ERIC Forum media) 4. Training users (source: website, e.g. webinar) 5. Catalogue of RI services (Source: website)	1. Knowledge and technology transfer (source: a liaison officer, event, Innovation Advisory Board, spin-offs / start-ups) 2. Engagement with industry, SMEs, spin-offs (source: Innovation Advisory Board, dedicated training and exchanges for industry, Industry Days) 3. Access policy for industry, business and public sector (source: website either as a separate Access policy or a part of the overall AP)	1. Criteria and narratives (source: studies assessing impact, case studies on website, ERIC Forum and RI-PATCH project) 2. Communication to wider public on impacts (source: website, social media) 3. RI contribution to RIS3 (source: RI roadmaps and RIS3)	1. Data access and management policies in line with EU Charter on Access to RIs (source: website) 2. Preparing for EOSC integration (source: website, EOSC Portal) 3. RI updates DMP over lifecycle (source: Data Policy) 4. Data produced by RI to be FAIR, open and accessible (source: Data access and/or management policies)	1. Presence of RI on national RI roadmaps (source: website, StR-ESFRI2 project) 2. RI business plan (source: Business Plan) 3. Financial planning to access EU funding instruments (source: Annual Report, Financial Statement / Balance Sheet) 4. Private funding for new services and technologies sought (source: Annual Report, Financial Statement / Balance Sheet) 5. Transparent cost calculation (source: Annual Report)	1. RI and services promoted at international and global levels (source: Annual Report, website, social media) 2. Dialogue with international partners (where appropriate) (source: Annual Report, website, GSO Report) 3. Promote EU standards and best practice in international fora (source: Data Policy)

Observations on the LTS Preconditions

We have observed that some patterns emerge from the analysis of the RI progress towards LTS that deserve general considerations.

ENSURING SCIENTIFIC EXCELLENCE

RIs in Europe are all strongly engaged in excellent science as their scientific objectives are born out of the highly international scientific communities and benchmarked at global level. The usage of the RIs is competitive as the access is based on internationally peer-reviewed proposals and quite often over subscription guarantees that merit-based access is delivered, in compliance with the EU Charter on Access to RI. In some cases however, a subcritical user pressure reduces the overall impact of the RI as the amount of excellent science produced could equally result from a network of collaborating research groups or institutes. The standard criteria of scientific productivity monitored by high impact publications and international science prizes are all met by the RIs that adopt them as a key-performance indicator. Data service Research Infrastructures may have no merit filters for the access, but nevertheless fulfil goal of excellent science, as unique time series or combination of observations are the basis of important research results.

The rapid growth of the RI model in all fields of research has different impacts on different communities. The long-established organisation of the physical sciences is centred on the usage of large instruments and infrastructures for observation, measurement or experimentation, while preparation of the experiments and data analysis and simulation are distributed activities, with frequent use of HPC-HTC infrastructures in remote mode. In the Environmental, Biomedical and Nutritional domains the RIs are all distributed and built on a centralised access system to data archives and services as well as to observation or experimental campaigns. Here the scientific communities are progressively engaging with the RIs, but the user pressure is, for some RIs, not yet very high as research in these fields can also be done in a more conventional academic manner so that researchers are not always aware of the competitive advantage of using a RI, or are sceptical about it. In the social sciences and humanities, the RIs are also often accessed in remote mode for data, data analytics and data services. In all cases an important key performance indicator should capture the relative size of the user community of the RI as a fraction of the research population in that field. Although not all RIs represent the unique reference instrument for research in a field, an indicator representing the involvement of the reference scientific community in the usage of the RI is fundamentally important as the investment in RIs is always a fraction of the total investment in a given field.

Excellent science is also produced by the network model, that is supported by the EU with Integration Actions for “starting” or “advanced” communities. In these cases, the RI resources made available for access, i.e. the capital equipment, come from the surplus capacity of academic and governmental laboratories that, with the contribution of the EU, can be shared with users through a peer-review based access system. The fine balance of IA programmes that include joint research and networking along with transnational user access enables increased scientific productivity of national or academic laboratories and exchange of researchers and research programmes, as the host researchers are helping the users to perform their science. Benchmarking of national and academic laboratories is a further benefit of this infrastructure action as it can lead to better focused investments by the owners of the participating laboratories and de-facto increases the complementarity of scientific institutions in the European research area. Training of young researchers through the access to RIs, or at dedicated schools organized by RIs has also become in several cases a key element of research training, although a formal connection with academic credits should be developed to have a full systemic impact on higher education.

The advantage in terms of excellent science productivity of a distributed RI versus a consolidated collaborative network offering infrastructure services is not always demonstrated and, in some cases, appears uncertain. Adoption of proper KPIs may help evaluating the most appropriate configuration, at a given time, for the provision of Research Infrastructure services. As argued in this report appropriate instruments should be developed by the EC in order not to force the well-performing access-providing research networks into the sole option of establishing a distributed RI.

Excellent science services of direct potential economic or social usage are embedded in several RIs providing unique monitoring of the planet (atmosphere, solid earth, volcanos, oceans) of the society (social perceptions, ageing, languages) or, for example, of the optimisation of different energy production options. In some cases, the move to market of these services implies crossing over to activities identified in the other pillars of Horizon Europe, adding a market-oriented business case to the excellent science objectives of the RI.

ATTRACTING AND TRAINING MANAGERS AND USERS

The rapid growth in the number of RIs has created a shortage of managers with the right level of skills. Large well-established organisations, like the EIROforum members, have a robust governance and management structure that enables the selection and progressive enrichment of the competences of their scientific, administrative and human resource directors. Their global impact also makes the competition for Directors fully international, which generally assures effective, high-level effective management. More recently established RIs are more exposed to risks of shortage of top managerial level personnel. Managing a RI requires competences that are often not in the background of the scientists who, having been principal investigators of the project that led to the establishment of the RI, have to cope with the complexity of tasks that are not always rewarding on the purely scientific level. The multi-national partnership of the RI with mostly public owners has implications in the management of the contributions, as the funding cycles may be different and the roadmap updates of different MS/AC are not aligned among themselves or with the ESFRI roadmap. Diplomatic skills, human resource recruitment and management skills, management of in-kind contributions, performance of an evidence-based socio-economic impact analysis as well as full technical understanding of commissioning, upgrade needs and evolving user and data policies must all be addressed by the top management of a RI. Recruiting 'the right people at the right time at the right place' in RIs has been recognised as a challenge by the ESFRI LTS analysis (ESFRI Scripta Vol. 2). Circulation of top managers among RIs is occurring, and the emergence of a RI-manager job market is a very positive sign for the overall upgrade of managerial quality of RIs.

Some RIs struggle to reach a critical mass of experienced scientists and engineers to carry out RI construction or transformational upgrade to schedule. In some sectors this is due to the sudden increase of demand of specific competences that traditionally belonged to a well-defined scientific sector and are now in high demand for the construction and operation of technological endeavours serving a broader variety of scientific communities. This is the case of accelerator physicists and engineers in high demand for analytical infrastructures (synchrotrons, free electron lasers) as well as for nuclear and particle physics infrastructures (colliders, ion accelerators). It is also the case for managers and scientists in high-performance/high throughput computer centres as well as data scientists, data communication technologists and data stewards who are now ubiquitous and whose shortage is one of the bottlenecks for the development of the EOSC.

The RIs cope in part by performing on-site training of young scientists, engineers and managers but in some cases, particularly DRIs, the unequal long-term job opportunities and economic treatment are obstacles in pursuing the alignment of the managerial layer of the national nodes to the required standard of the hub.

The EU has supported training of RI managers through the RAMIRI and later RItrain actions like the Executive Masters in RI management of the Univesity of Milano-Bicocca to address the skills issue. A further effort in establishing academic paths and career paths in the field of RI management is needed.

Attracting users to excellent RIs depends also on transparent, merit-based access procedures. The catalogue of services is an important instrument that should be further developed in all RIs, possibly with cross-links to other RIs. An interoperable catalogue with other RIs in the same science domain could be a building block to realise the interoperability of the pan-European RIs that is needed to addressing complex questions such as those identified by the Missions and Innovation actions of Horizon Europe.

An important issue is the capability of an RI to attract added value from users, notably in sharing with selected user groups the responsibility of design of upgrades and construction of parts of the infrastructure. High scientific and technical capabilities are present in the European research and academic institutions that could be better engaged in the design and construction of RI instruments and services. This requires managing suitable agreements that stimulate the, often unique, contribution, by highly qualified researchers, in exchange for scientific return. Broad participation in the development of a RI should be one measure of success and LTS of the RI, as its embedment in the ERA will be enhanced.

UNLOCKING THE INNOVATION POTENTIAL OF RIS

RIs are drivers of innovative procurement as the technical needs for their construction or upgrade often greatly exceed what is available on the market. For industry supplying to RIs has both financial and skill upgrade benefits. The innovation potential of access to the RIs is less direct and only very partially reflected in patents and their exploitation by industry. A common pattern of the user communities of analytical RIs is the "hidden" usage by industry by means of academic access in the framework of industry-university research contracts. RIs can increase the potential of direct innovation by users by offering tailored access modes for industry (particularly SMEs), possibly including training and data exploitation support whilst preserving the often-demanded competitive secrecy.

The Social Science and Humanities, Environment, Biology, Health and Nutritional infrastructures will develop their innovation potential with FAIR data and data services becoming progressively open to the economic sector at a future stage of the EOSC.

MEASURING SOCIO-ECONOMIC IMPACT

Most RIs adopt KPIs that reflect impact on local or general economy, society at large and the local community. A few examples of studies on the social cost-benefit analysis of the infrastructures exist that adapt cost-benefit models to the specific case of RIs. No uniform methodology is in place and the RIs can only address this issue in a non-standardised manner which makes it hard to measure and benchmark impact. This point has been addressed in different reports (OECD, RI-PATHS).

EXPLOITING BETTER THE DATA GENERATED BY RI

Major scientific data producers have developed good practice in data archiving and retrieval over several decades. This is notably the case for the astronomy/astrophysics observatories and high-energy particle instruments analytical facilities. ESFRI has put pressure on the RIs since the 2016 Roadmap to develop data management plans and to express the e-needs, i.e. the quality and volume of interfaces with the external data networks, archives, HPC and HTC needed for the full exploitation of the research data produced. The GSO started a data working group that has evolved into the Research Data Alliance (RDA). The more recent European strategy for realising a European Open Science Cloud is benefiting from the most advanced data archives and services provided by the RIs (e.g. ELIXIR, EPOS ERIC, ESRF, LifeWatch ERIC) contributing to the first federated core of services. At the same time EOSC puts pressure on all RIs open to international usage to make the data sets FAIR and to contribute to developing interoperable services for the scientific community at large and reaching out to innovation, mission-oriented research, educational, economic and social activities.

THE OPEN DATA PARADIGM AS AN ELEMENT OF LTS FOR RIS AND THEIR CONTRIBUTION TO THE EOSC

The e-infrastructure component of most Research Infrastructures has developed greatly over the last twenty years as a key element for supporting research communities. For the 2016 Roadmap, ESFRI introduced a check in the selection process of the e-Infrastructure needs and planned developments with a rule of thumb that at least 15-20% of the investment in the new RI should be devoted to its e-Infrastructure.

Many RIs occupy leading positions as building blocks of the development of the EOSC and as participants of the H2020 INFRA-EOSC projects, individually or within H2020-Clusters. ELIXIR, EPOS, ESRF, CESSDA and others provide state-of-the-art references of the most advanced data management solutions for fulfilling the FAIR principles and feeding quality-controlled datasets into the future EOSC.

RIs are often at the forefront of data formatting, curation, archiving and access, but less so on interoperability. The effort towards interoperability has structural and financial implications that must be addressed with the RIs, in a concerted and well supported manner.

Sustainability of the EOSC and of the RIs are interlinked. Very likely the real way to an effective EOSC implies that all new datasets must be FAIR from the acquisition stage (FAIR by design) as the FAIR retrofitting of existing datasets will be limited to essential time-series or to observational data that intrinsically cannot be acquired again.

'FAIRification' of existing data sets will imply criteria of choice, or a system enabling the FAIRification on-demand, provided a metadata open access environment is established at the core of EOSC.

Acquiring FAIR data by design implies large instrumental investment (hardware and software) as the complementary data to create metadata must be acquired in automatic manner to reduce the extra work of researchers to a sustainable level. This must be part of the planning and financial management of the RIs, with an analysis of the expected impact of those datasets once available through the EOSC.

The percolation of good practices at RI level to the reference research communities, as well as active training of data scientists and data stewards at academic level, can enforce a robust EOSC capable of engaging the 'long tail of science' with assurance of robust data-quality checks.

FRAMEWORK CONDITIONS FOR EFFECTIVE GOVERNANCE AND SUSTAINABLE LONG-TERM FUNDING FOR RIS

Ensuring sustainability of the investment concerns all stages in the lifecycle of a RI. The development of a robust, and flexible, business plan is key to define the proper governance and identification of the stakeholders beyond the reference research community. Good planning and timely availability of implementation/construction costs and contingency are often problematic. The typical consequences of approximate cost-books are delays in the completion of the RI, descoping, increase in cost, delay of the return on investment and loss of overall competitiveness at international/global level. Once the RI opens to users the problem becomes one of ensuring its sustainable operation for the designed number of years/decades, hopefully at maximum capacity.

Systemic issues that impinge on sustainability are connected to general economic cycles that modulate the investment capacity or willingness of governments and stakeholders to commit funding. A framework condition should therefore be the overall alignment in time of the national roadmaps and the ESFRI roadmap in such a way that new entries are already present in the national roadmaps of the participating MS and AC and reflected in national research budgets.

Another framework condition could be the adoption of the proposed Readiness Level paced lifecycle in which the EU and the prospective members jointly finance the RI from the early implementation stage, with a progressive switchover from European to (multi) national budgets rather thanthe sudden appearance of an all-new entry in the national budget when the RI needs the formal decision to build and operate.

STRUCTURING THE INTERNATIONAL OUTREACH OF RI

RIs reach out of Europe in terms of attraction of international scientists, as well, in some cases in terms of global governance when the RI is unique at world-level or when it is based on multiple observation sites located in different continents. The GSO addresses the opportunities of global RIs and several pan-European RIs have proposed their global role in that framework. The GSF performs a horizon scanning activity at OECD level identifying general trends.

There is a clear function of science diplomacy that is connected with the individual RIs that involve different international communities, or that, being based in the EU, also offer services to non-European countries. There is a systemic attraction to structuring international outreach that is reflected in the collaborative programmes like CREMLIN (EU-Russian Federation) or EU-CELAC (EU-Central and Latin Americas) on Research Infrastructures, stimulating the adoption of the RI model by the non-European partners and fostering exchange of scientists and common Design Studies or programmes. There are also possibilities that individual RIs can pursue internationalisation in domains such as ocean and earth observation, nutrition, environmental changes monitoring and protection, biodiversity, cultural heritage science, or analytical science where expanding the access and ultimately the data base are key to accelerating the scientific productivity and advance.

Assessment of Individual Research Infrastructures

The Individual RI assessments of the 43 selected RIs are provided as Annex A. They are arranged in two groups, Single-sited Research Infrastructures (SRIs) and Distributed Research Infrastructures (DRIs) described below.

SINGLE-SITED RESEARCH INFRASTRUCTURES (INCLUDING MULTIPLE-TECHNICAL SITES)

We have defined Single-Sited Infrastructures are those resources for observation or for performing experiments that are based on major installations in a single site or in a few sites (typically 2 or 3) that operate as a unique instrument or as instruments performing parts of a unique observation or experimental process. This is slightly different to the ESFRI description and recognises that ELI and KM3Net share major characteristics with single-sited RIs.

The list of the Single-Sited RIs assessed follows:

RESEARCH INFRASTRUCTURE	CATEGORY	TYPE
CTA	**Landmark**	**Single-sited**
EISCAT_3D	**Landmark**	**Single-sited**
ELI	**Landmark**	**Single-sited**
EST	**Project**	**Single-sited**
European Spallation Source ERIC	**Landmark**	**Single-sited**
FAIR	**Landmark**	**Single-sited**
KM3NeT 2.0	**Project**	**Single-sited**
SKA	**Landmark**	**Single-sited**
KM3NeT 2.0	**Landmark**	**Single-sited**

DISTRIBUTED RESEARCH INFRASTRUCTURES

Distributed Research Infrastructures are those resources for observation, performing experiments, providing access to collections and data, coordinating multidisciplinary research, performing computational analysis, that are based on central hubs providing coordination of the scientific programme and the single entry point for users to multiple installations and facilities of national dimension acting as nodes.

DRIs are the most numerous RIs and dominate the environmental sciences, the bio-medical and nutritional sciences, the social sciences and humanities..

The list of the Distributed RIs assessed follows:

RESEARCH INFRASTRUCTURE	CATEGORY	TYPE
ACTRIS	Project	Distributed
AnaEE	Project	Distributed
BBMRI ERIC	Landmark	Distributed
CERIC ERIC	Other	Distributed
CESSDA ERIC	Landmark	Distributed
CLARIN ERIC	Landmark	Distributed
DANUBIUS-RI	Project	Distributed
DARIAH ERIC	Landmark	Distributed
E-RIHS	Project	Distributed
EATRIS ERIC	Landmark	Distributed
ECCSEL ERIC	Landmark	Distributed
ECRIN ERIC	Landmark	Distributed
ELIXIR	Landmark	Distributed
EMBRC ERIC	Landmark	Distributed
EMFL	Landmark	Distributed
EMPHASIS	Project	Distributed
EMSO ERIC	Landmark	Distributed
EPOS ERIC	Landmark	Distributed
ERINHA	Landmark	Distributed
ESS ERIC	Landmark	Distributed

EU OPENSCREEN ERIC	Landmark	Distributed
EU-SOLARIS	Project	Distributed
EURO-ARGO ERIC	Landmark	Distributed
Euro-BioImaging ERIC	Landmark	Distributed
IAGOS	Landmark	Distributed
ICOS ERIC	Landmark	Distributed
INFRAFRONTIER	Landmark	Distributed
INSTRUCT ERIC	Landmark	Distributed
ISBE	Project	Distributed
JIVE ERIC	Other	Distributed
LifeWatch ERIC	Landmark	Distributed
MIRRI	Project	Distributed
SHARE ERIC	Landmark	Distributed
WindScanner	Project	Distributed

THE EIROFORUM GROUP

Created by Charter in 2002, EIROforum currently has eight members (CERN, EMBL, ESA, ESO, ESRF, European XFEL, EUROfusion and ILL). While the members have a range of legal structures, they collectively describe themselves as European Intergovernmental Research Organisations. RI projects of some EIROforum Members are present in the ESFRI Roadmap as Landmarks or Projects as (eg High-Luminosity Large Hadron Collider (HL-LHC) of CERN, the ILL 2020-instrumentation upgrade (ILL), The Extreme Brilliant-Source of ESRF (ESRF EBS), the Extremely Large Telescope of ESO (ELT) and the European X-FEL). In addition, ELIXIR that originated as a special project of EMBL, evolved into an independent ESFRI Project/Landmark and a recent new EUROfusion project, IFMIF-DONES, has also become an ESFRI Project to enable the application by some Member States to structural funds to finance the construction.

In a 2015 discussion paper on the Long-Term Sustainability of Research Infrastructures[24], EIROforum identified five main criteria that they considered enable RIs to be sustainable in the long term:

- Relevance of an RI to its scientific community and the ability to generate scientific excellence
- Sustainable governance model and legal framework
- Sustainable funding model
- Ability to attract scientific talent and build a critical mass of scientific expertise
- Socio-economic impact

Despite the differences in legal status and scientific mission the EIROforum members share a number of characteristics, which have major positive impacts on their long-term sustainability and enable them to address the above issues.

The EIROforum RIs tend to be seen by their research communities (and Member State Governments) as the primary vehicles for delivery of scientific excellence in their respective fields. In some cases, they provide unique access to capabilities that cannot be afforded by a single Country, while in other cases they integrate national RIs with unique capabilities that are not available in those national facilities.

A key feature of all EIROforum members is their stable long-term governance and legal structures. Regardless of their individual legal structures, which range from Treaty Level Organisations to Companies established under the Host State law, as Intergovernmental Research Organisations, EIROforum RIs benefit from strong buy-in from their member states, enshrined in intergovernmental treaties and conventions. Their missions and long-term strategies are endorsed by these member states who are strongly represented in the top levels of the governance structures.

Generally speaking, EIROforum organisations benefit from long-term financial planning via sustainable funding models. When approving new projects or major upgrades EIROforum governing bodies agree not only on the plans to secure capital investment but also on plans for long-term funding of operations. In many cases the role of the EIROforum organisation transcends a particular facility or instrument. For example, CERN has a specific mission to support high-energy physics in Europe, while ESA delivers space science and earth observations and other space applications for Europe via a

[24] https://www.eiroforum.org/wp-content/uploads/20150325_discussion-paper-research-infrastructures-sustainability.pdf

rolling programme of missions, and ESO has developed into Europe's world leading focus for ground based optical, infrared and sub-mm ground-based astronomy. In other cases, members of EIROforum provide world-class facilities that by their nature, rely on constant instrumentation replacement and periodic major upgrade both of which require financial commitments to go beyond one-off capital investments.

A further characteristic of EIROforum members is that they employ significant pools of scientific, technical and administrative staff (in most cases directly employed by the organisation). This represents a major focus of human talent, able to collaborate with a wider community of engineers and scientists to address major scientific challenges. Key to this is the ability to attract scientific talent and build a critical mass of scientific expertise. In this regard, success breeds success and the world-class nature and prestige of the EIROforum organisations ensures that they are able to attract and retain some of the best talent in Europe and indeed the world. Training is a key part of this activity and it benefits both the individual organisations and the wider European community via the number of scientists and engineers who spend part of their professional training and development in the EIROforum organisations.

While a number of the EIROforum RIs are aimed at curiosity driven fundamental science, they all succeed in delivering significant socio-economic impact. This impact comes in many forms including impact on the local economies of the regions where they are sited, technology development with wider applications, stimulation of interest among the wider community in science and engineering and of course scientific results with direct application.

The majority of the EIROforum members have been in existence and successfully producing world-class scientific results for many decades and have demonstrated their long-term sustainability. Overall it is clear that via their focus on scientific excellence, their stable governance and sustainable funding model funding with clear links to Member States, their critical mass of scientific and technical expertise and their socio-economic impact, the EIROforum RIs represent a successful model for long-term sustainability with wider applicability to other RIs.

Analysis of results by research domains

ENERGY RESEARCH RIS (ENERGY ESFRI SWG)

As a consequence of the exclusion of the RIs connected with the EURATOM treaty, only three RIs in the Energy research domain were assessed, ECCSEL, EU-SOLARIS and WindScanner. The whole sector is interlinked by the global attempt to control and limit CO2 concentration in the atmosphere by reducing emission and developing effective technologies of capture and storage.

The sector has been described by ESFRI in the Landscape Analysis and has cross-fertilisation aspects with Environmental science research, Health and Nutrition research, Physics and Engineering, and the Social Sciences and Humanities. Its relevance for global challenges is clear, but the lack of convergent policies makes the agenda for innovation in this field difficult and this is reflected in our assessment of the sustainability of the RIs in this domain. Bottlenecks arise from the difficulties in establishing sustainable business cases or clear added value of RI structures as opposed to stable, well-structured research network configurations. Networking among national facilities encounters difficulties in scaling up investments at multinational level, although a rationalisation of efforts at the EU level is progressing. RIs closer to the market need to develop clear-cut strategies with respect to the commercial sector. It is noteworthy that EU projects like SHAPE ENERGY-H2020 address the Social Science and Humanities implications of the energy research agenda.

ENVIRONMENTAL RESEARCH RIS (ENVIRONMENT ESFRI SWG)

The Environmental RIs assessed represent an asset for European research that covers the solid earth (EPOS), marine (EMSO, EURO-ARGO, DANUBIUS-RI), atmospheric (ACTRIS, EISCAT-3D, IAGOS, ICOS) and ecosystem (LifeWatch) sectors with interconnected observatories, experimental stations and fast developing data archives and services. All RIs have a representative membership but still need to expand, both for effective coverage of the European territory and for ensuring long-term sustainability of core services.

There is work ongoing as regards Interoperability of data.Certification of FAIR data services should be further developed in a joint manner, contributing to setting the data quality standards of the EOSC, and adding value to the datasets (and to their owner institutions). Cluster projects are effective, and the data practices are in some cases quite advanced accross the whole sector.

Although access practices are generally aligned with the 'European Charter for Access to Research Infrastructures', there is still some work to do in assuring the full exploitation of the resources made available by the RIs. Some communities are not yet fully engaged in using the RIs and/or contributing to their full development, and the actual size of user communities must be continuously monitored. This has to do with insufficient communication of the benefits, results, opportunities and overall offer created by the RIs.

The RIs should continuously monitor and update the dynamics of their user communities as well as identify the new communities that, as interoperability tools develop (e.g. virtual access and personalised services), could be reached.

One common bottleneck is the need for well trained RI operators, administrators and developers. This is addressed by most RIs with specific training programmes, but an overall sectoral action could be organised and offered as academic specialisation for scientists of the relevant disciplines.

Integration of activities of the RIs is favoured by the H2020 'cluster' INFRADEV projects. We recommend evaluating organisational coordination or merging where appropriate, in order to represent a broader spectrum of RI and data services for research on the natural environment, capable of fostering innovation and informed policymaking. The services for industry also need to be further developed in order to enrich the business plan.

BIOLOGY, HEALTH AND NUTRITIONAL RESEARCH RIS (HEALTH & FOOD ESFRI SWG)

The Biology, Agri-Food or Nutritional, and Medical Sciences represent a very dynamic domain where RIs are flourishing with diverse degrees of maturity and access by industry and public services. The central role of this sector for European competitiveness and well-being has prompted the establishment of RIs addressing specific aspects of the Health challenge (BBMRI, EATRIS, ECRIN, ERINHA, Euro-BioImaging) for the EU as well as the nutritional challenge (AnaEE, EMPHASIS, MIRRI, METROFOOD-RI) both inside and outside the EU. Basic research in biology is supported by INSTRUCT, EU-OPENSCREEN, INFRAFRONTIER, and MIRRI.

All initiatives in this domain are developed as distributed Research Infrastructures and encounter the typical bottlenecks of aligning legal and strategic investments at national level. In some cases, an insufficient analysis of the size of the actual user community becomes a bottleneck in the Implementation Phase. The overall public funding, at EU and national level, is substantial but synergies are not always fully exploited. The European recognition of the key role of some RIs with implications for personal data policies or commercialisation policies is a general bottleneck that cannot be addressed by the individual RIs and requires a concerted effort.

Communication to the public and to national authorities of the current and potential impact of the ensemble of the RIs in the sector is also needed and might be enhanced if a common strategic plan were developed. There is coordinated work on data management, access and analysis, but evidence-based communication of results must be enhanced. Academic investment practices are still often self-referential, resulting sometimes in limiting factors for the effective usage and exploitation of advanced instrumentation, which has general implications on sustainability and effective use of resources. Well established and effective networks, e.g. in Plant Phenotyping, remain somewhat external to some RIs and an overall offer of infrastructure services is missing, resulting in limited impact. Careful impact analysis of the planned services should drive towards a decision to integrate existing RIs in this domain with valuable extra services rather than starting a new RI with uncertain sustainability.

Cluster projects are structuring efforts in building and making available multi RI catalogues of services and resources. Alignment with the development of EOSC should become a priority for the whole sector.

The RIs of this domain have strong interfaces with the RIs of the Environmental research, Social Sciences and Humanities, Physical Sciences and Engineering Sciences and Digital domains.

SOCIAL SCIENCE AND HUMANITIES RESEARCH RIS (SOCIAL & CULTURAL INNOVATION ESFRI SWG)

The ESFRI RIs in the Social and Cultural Innovation domain that have been on the roadmap for 10 years or more have all reached the Landmark status and adopted the ERIC legal structure (CESSDA, CLARIN, DARIAH, ESS, SHARE). In spite of this success, issues remain in ensuring LTS mostly due to limited engagement in sustained funding by a critical mass of partners and to incomplete coverage of the European MS and AC communities. Those RIs that gather their data from surveys are particularly penalised by the absence of contributions from important areas of Europe, which limits the otherwise advanced analysis of these data and their overall impact.

Integration of the catalogue of services provided by these RIs would strengthen the overall impact of this sector that has proven its organisational capability and is advancing towards the adoption of FAIR data standards. The novel concept of Heritage Science (E-RIHS) with the multidisciplinary approach needs to be strengthened. User access should be monitored, and support measures should be developed beyond the reliance on EC support.

The social sciences and humanities RIs intersect and complement the research potential in all the other domains. This aspect must be acknowledged and strengthened by systemic actions.

PHYSICAL SCIENCES AND ENGINEERING RESEARCH RIS (PHYSICAL SCIENCES & ENGINEERING ESFRI SWG)

The RIs in this domain are uniformly single-sited. The main issues regarding LTS are financial as costs are high in absolute terms. The user communities are well identified, numerous and often global. The data production and management are converging towards FAIR practices. Impact beyond the fundamental discoveries from observations and experiments is measured by technological spin-out to industry and applications in broad domains from health to sensors and communication technologies. The multi-messenger paradigm is spreading from the observation of the universe to the integration of data from interaction of particle beams with inorganic and living matter.

The bottlenecks for the large single-sited RIs of the Physical Sciences and Engineering group in the early stages of their lifecycle include the lack of firm engagement by founders, i.e. Member States and Associated Countries that hesitate to include the new RI on their national roadmap or to join the process to establish a legal frame (ERIC or other) with financial commitments. The RIs have the support of the reference international scientific communities, but this does not translate into the engagement of the respective governments. Setting up a board of governmental representatives, the prototype of a Council, in the early stage can be beneficial in avoiding the Preparatory Phase being a purely EU FP activity and delaying the real ownership issues of the RI.

Large in-kind contributions, common in this sector, facilitate the participation of MS and AC in large projects, but they also present a new kind of risk as delayed or unsuccessful delivery of IKCs impact the whole construction, induces delays and requires reorganisation of workflow that, even when possible, implies severe revision of costs and financial plans. Contributing a large IKC towards the construction cannot be decoupled from the simultaneous decision to contribute to operations, but this often occurs and is a bottleneck for the RIs to reach sustainability.

In some cases, the new RIs are expected to replace existing obsolete or lower performance RIs. However, the transfer of resources from the latter to the former are hard to realise as national communities or Governments may not be willing to discontinue existing facilities resulting in long periods of overlap often being needed to avoid dangerous discontinuity of the research programmes. This results in strains in the budgets.

Internationalisation is high in this domain and some of the RIs have a clear global dimension and global impact on science. Management of the human resources needed to build and operate large facilities can be a bottleneck in some cases as the competences that are required are not always available when several projects need to progress simultaneously.

Insufficient accuracy and reliability of costing and risk analysis (with inclusion, from the beginning, of multi-annual projected costs for operation) also represent a bottleneck on the road to firm participation and funding commitments. While this may be a tactical approach to facilitate a decision to move ahead (start implementation, be accepted on the ESFRI Roadmap, obtain EC support, the appearance of extra-costs hampers the implementation process and causes delays that in turn add further cost and loss of competitiveness. The adoption of the Readiness Level gated process is likely to introduce a healthy element of rigour and clarity in the RI decision/implementation process and to set a solid basis for LTS.

The substantial investment in large new RIs tends to increase with schedule slips due to delayed construction and/or suboptimal cash flow. External political factors may represent financial bottlenecks. For example, the long-standing issue of the exemption for in-kind contributions (IKC) of the national value-added taxes (VAT) has a very sizable impact on cost (20-22%). The cost analysis at the Preparation Phase is seldom respected and the planned contingency cannot cope with the reality of increased costs.

RIs developed in the frame of parent institutions have advantages with respect to green-field constructions, as institutional and technical support as well as highly qualified manpower are already structured and can be available to some extent. On the other hand, these RIs have a harder time in establishing a new international partnership and governance, resulting in purely in-kind contributions and no real engagement in the long term by other partners, meaning they remain essentially national undertakings with international scope, facing financial and human resource bottlenecks.

PATTERNS IN RI LIFECYCLE

We have observed that some patterns emerge from the analysis of the RI progress towards LTS that deserve general considerations.

THE PREPARATION PHASE

Preparation of a RI concept and design are generated by the scientific community in a bottom-up approach that may arise from:

- Accumulated experience in sharing existing national resources (via for example Integration Actions).

- From outlook exercises by scientific societies and ERA-NETs like ASPERA, AppEC, NuppEC.

- Or as upgrade projects or all-new installations designed by the EIROforum members as part of their continuous upgrade of resources to accomplish their missions.

RI projects can develop at national level but ESFRI has become a reference collector of projects of pan-European importance and plays an important role in selecting those with sufficient maturity.

The preparation phase is crucial to establish solid foundations for a new RI. The first step is to adequately assess and communicate the potential for a scientific paradigm shift, the quality and quantity of the science that will be supported, and the size of the user community (and/or the measures to support its growth to the level that will justify the investment).

A validated cost-book and contingency is crucial to prevent shortcuts and rough estimations that erode the credibility of a RI project. Rigorous cost-book and human resource budget checkpoints are required.

Members of a RI should have a long-term perspective of their investment, including construction, the decades of operation and the decommissioning. The latter includes the residual value at the end of operation when reorientation will be considered if possible, or just the cost of removing unnecessary or potentially harmful installations once the science programme is accomplished.

The plan must also include the mechanisms for monitoring the elements above during the whole lifecycle.

THE IMPLEMENTATION/CONSTRUCTION PHASE

European science is very dynamic in developing concepts of excellent Research Infrastructures in all domains of science, but the implementation of even the best projects is sometimes slow with respect to other global competitors. Major installations on green fields are accomplished in 5-7 years elsewhere whilst pan-European projects may take 10-20 years to be built. This is generally a competitive weakness (in terms of science delivery and costs), with a few remarkable exceptions.

The strategic road-mapping exercises pioneered by ESFRI and those adopted by most MS and AC are seldom in phase, and the lack of timely adoption of pan-European RI projects by national roadmaps is a bottleneck for implementation as national RI budgets are aligned with national roadmaps.

Procurement processes are more complex and time consuming in Europe, hampering co-creation with the private sector. Territorial constraints and related legal issues are also more challenging in Europe. Inadequate planning in the construction of the RIs adds to these intrinsic constraints of the European system.

The Construction Phase should not start without adequate financial planning for timely completion and operation. A risk analysis should be carried out to ensure that contingency measures are adequate.

These considerations do not only apply to capital intensive RIs involving substantial investment in one or a few related sites; they are also relevant for the central hubs of distributed infrastructures and the upgrade/alignment of the distributed nodes. Nodes managed on standard national budgets may not become effective parts of a pan-European RI without the required extra resources, and the hubs cannot become effective with purely in-kind contributions by the nodes.

We found some RIs to be only at readiness levels RL2-4 in spite of the fact that the time and effort already dedicated to the project would justify expectations of fulfilment of RL5 (i.e. of an operational and scientifically productive RI). Learning from these shortcomings must lead to better management of the portfolio of pan-European RIs, careful evaluation of new initiatives and timely adoption by national roadmaps of the commonly agreed RIs.

THE OPERATIONAL COSTS BURDEN

One common bottleneck for RIs, is to ensure adequate funding of their operational costs. These costs are often of the order of 10% of the initial construction investment per annum, but are too often treated as a separate issue to the construction budget. The delivery of science is the very reason why the RI was designed and built, but this productive phase turns out to be a bigger financial problem than the construction.

There is no logic in building a very expensive RI and then operating it at a low capacity due to restrictions of operational budget, jeopardising the overall science return.

On the RI side, a culture of 'costing' must be fostered. Not having a completed and validated cost-book is a pitfall of most RIs, and the risks connected with unknown cost influence decisions. RIs that experienced large increases of cost, not foreseen or covered by contingency, put a stress on the whole system. One alternative planning instrument could be to reverse the budget engineering and to evaluate what operational costs are considered sustainable for the 20-50 years during which the successful operation will generate return, then trace this back to determine the initial maximum investment size.

Much of the operational cost burden has to do with poor planning, poor design of the RI, and poor governance and management from the initial stages. Specific checkpoints must be established in a business plan that covers the entire lifecycle of the RI.

THE RI CLUSTERING

Thematic H2020 RI clusters and transversal clusters as those in the INFRAEOSC grants allow for an effective coordination of efforts and adoption of good practices. Some RI clusters offer pilot programmes of access to the participating infrastructures by single proposals from users that justify the need of combined access to more complementary infrastructures. Advanced models to implement this approach are also present in IA ongoing actions (e.g. the TLNet of NFFA-Europe), which shows the evolution towards the interoperability concept of the RI ecosystem.

CONCLUSIONS OF THE HLEG EXERCISE

This HLEG exercise has addressed the effectiveness of the EU measures to support Research Infrastructures.

RIs constitute one of the backbones of the European Research Area, and offer world-class or world-leading scientific services to European scientists. The use of RIs has become an essential tool in the competitive research of all scientific communities. This has been accomplished in part thanks to the Transnational Access programmes.

Nevertheless it appears that EU measures have not been as effective as they could have been in achieving timely implementation of RIs, full sustainability of operations and ultimately full scientific return on investment.

We have proposed a new approach, based on a staged sequence of support actions, regulated by a grid of Readiness Levels that map the lifecycle of the RI from design to full operations. The proposed support scheme is based on research contracts, jointly funded by the RI proponents, that set as objectives the achievement of the next Readiness Level and that cannot be activated if the previous RL has not been reached (as certified by a suitable authority established by the EU).

We have assessed a subset of RIs of pan-European or Global interest applying our Readiness Level analysis, and have indicated bottlenecks and formulated recommendations.

Some critical issues resulting from our assessments require a concerted action at the RI level but also at national and EU levels in order to improve efficiency and effectiveness of the decision making and of the continuous curation of the RI system.

Novel measures for assuring long-term effectiveness of Research Infrastructure services are needed, based on the organised sharing of competences and surplus capacity at leading European research institutes and academic laboratories. The full deployment of competitive services cannot be pursued by implementing an ever-growing number of autonomous legal RI entities. Clustering should lead to higher efficiency. Interoperability of RIs for new data production as well as for FAIR data exploitation must also be supported.

Overall the European RI system is delivering excellent science, with many examples of absolute international leadership. The RI system has a structuring effect for the ERA, but more effort is needed in order to coordinate investments in research and to facilitate the use of RI services across all scientific fields.

We are thankful for the help provided by EC staff, who assisted us in our work during a year of internal organisational changes in the Directorate General for Research and Innovation.

ANNEXES

Annex A Individual Assessments of Research Infrastructures

Individual Assessments of the 43 selected RIs were drawn up using the standard template below.

TEMPLATE OF THE INDIVIDUAL ASSESSMENTS

SCIENTIFIC DOMAIN	
LOGO	**ACRONYM NAME**
Description of the Research Infrastructure, its scope and role in the ERA Landscape	

Typology RI	Single-sited or Distributed
Lead Country	MS/AC (ISO CODES OF Member States and Associated Countries)
Members	MS/AC (ISO CODES OF Member States and Associated Countries)
***Observer (ERIC)**	MS/AC (ISO CODES OF Member States and Associated Countries)
Prospective Members	MS/AC (ISO CODES OF Member States and Associated Countries)

<table>
<tr><td>ESFRI Roadmap Entry</td><td colspan="5">YEAR, when relevant</td></tr>
<tr><td>ESFRI Landmark</td><td colspan="5">YEAR, if relevant</td></tr>
<tr><td rowspan="5">Preparation</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU Contribution to project)</td><td>EUR M (Total cost of the project)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TOT</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">EUR YY Million (EU funds) / ZZ Million (total funds)

This entry provides:

• The EU funds used by the RI for its preparation phase (including Design Study, Preparatory-Phase I and II grants (FP7-INFRASTRUCTURES, H2020-INFRADEV))

• The total funding used for the RI preparation phase includings the previous figure (EU funds) plus the extra funds from national sources that concurred to the preparation.

• The costs quoted in the ESFRI Roadmap 2018 for preparation and construction

Data are from the EC (Cordis database).</td></tr>
</table>

<table>
<tr><td rowspan="5">Implementation/ Construction</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU Contribution to project)</td><td>EUR M (Total cost of the project)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TOT</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">EUR YY Million (EU funds) / ZZ Million (total funds)

This entry presents:

• the EU funds used by the RI for its development and construction, including Implementation Phase grants (FP7-INFRASTRUCTURES, H2020-INFRADEV)

• The total funding that includes the previous figure (EU funds) plus the extra funds from national sources that concurred to the preparation.

Data are from the EC (Cordis database).</td></tr>
</table>

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (**EU Contribution to project**)**	**EUR M (**Total cost of the project**)**
	TOT			
	This entry compiles total EU funding for collaborative grants where the RI participated as one of the beneficiaries: H2020-INFRASUPP, H2020-INFRAIA, H2020-INFRADEV and H2020-INFRAEOSC (including CLUSTERS) and other FP7 projects (FP7-INFRASTRUCTURES, FP7-ICT) involving multiple RIs providing support towards the development of aspects directly related to the implementation of the concerned RI at technical, scientific and organizational level. *Data were retrieved from the EU's Cordis database.* *TOTAL SUMS are listed, without breaking down the amounts for each beneficiary. The objective is to provide an indication of the overall support provided by the EC to address common issues of the RIs. The benefit for the RI from the collaborative grants is not limited to its part of the grant's budget, but from the collective development of solutions.*			
Legal Status	ERIC, AISBL, GmbH, Societè Civile and similar and the year of establishment			
In Operation since	YEAR			

Implementation Readiness Level and Future Outlook Description of status and readiness. The HLEG assesses the current Readiness Level **RLX**. The outlook for achieving the next RLX+1 is indicated when relevant.
Long-term Sustainability Description of state of play of the RI with reference to the pre-condition for LTS defined by the 2018 EC Staff Document on LTS. The document presents in **bold letters** the pre-conditions that deserve specific comments e.g. **excellent science** objectives, **innovation** related issues, **socio-economic impact**, etc
Major Bottlenecks and Possible Measures Which Might impact Further Development Description of the main bottlenecks identified by the HLEG, based on public information and on the RI's written input. Bottlenecks concern the current RIs status and RL, the path to reach the next RL, and in general the prospects to guarantee full operation and full return on investment.
Recommendations The HLEG presents recommendations for addressing the bottlenecks at the current lifecycle stage and in view of achieving full deployment of the RI programme and its long-term sustainability.

SINGLE-SITED RESEARCH INFRASTRUCTURES

CTA

PHYSICAL SCIENCES & ENGINEERING	
	CTAO (previously **CTA**) Cherenkov Telescope Array Observatory
CTAO is a Research Infrastructure for ground-based very-high-energy gamma-ray astronomy. It will extend the study of the astrophysical origin of gamma-rays at energies of a few tens of GeV to hundreds of TeV, and investigate cosmic non-thermal processes.	

Typology RI	Single-sited				
Lead Country	DE for CTAO-Gmbh, IT for CTAO-ERIC under evaluation				
Members	DE for CTAO-Gmbh, IT for CTAO-ERIC under evaluation				
***Observer (ERIC)**					
Prospective Members					
ESFRI Roadmap Entry	2008				
ESFRI Landmark	2018				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	CTA-PP	2010-2014	5.2	8.0	
	TOT	2010-2014	5.2	8.0	8

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	CTA-DEV	2015-2019	4.3	5.0	
	TOT	2015-2019	4.3	5.0	297
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ASTERICS	2015-2019	15.0	15.0	
	ESCAPE	2019-2022	16.0	16.0	
	TOT	2015-2022	31.0	31.0	
Legal Status	GmbH, since 2014 (ERIC under evaluation)				
In Operation since	Foreseen 2024 (Currently in Construction Phase, ESFRI Landmark)				

Implementation Readiness Level and Future Outlook

CTA has been on the ESFRI Roadmap since 2008 and achieved Landmark status in 2018. In 2014 the funding Agencies established a legal entity under German law with a scope of preparing the construction of the Observatory on two sites, the Canary Islands and Chile (the hosting agreement with Chile was signed in December 2018). It was established that the Construction Phase should start once the new legal entity, CTAO ERIC, was in place. As the process towards applying for the ERIC status started in 2019, the CTA Management foresees the start of the construction at the beginning of 2021. Prototypes of the telescopes are in place. CTA involves a community of 1500 researchers from more than 200 institutes in 31 countries. CTA is assessed at **RL3**. CTA has applied for ERIC status and will complete and approve an advanced cost-book, which is preliminary to full-size construction and progress towards RL4.

Long-term Sustainability

The modes of access, via the Key Science Programmes or via open access by qualified application for observing time, need to be defined, as well as the ownership of data. The possibility of having a large community of scientists extending beyond that of the member countries should be considered. The Ri governance should adopt appropriate solutions to guarantee the necessary resources for the Operation Phase of the Observatory and for the periodic upgrade of the scientific instrumentation. The design of the telescopes will remain unchanged for the lifetime of the Observatory, but the cameras could benefit of new technologies under development in other sectors of physics and require upgrades, to be foreseen and funded at regular intervals of e.g. ten years. Although there is a policy in place that encourages **industry**, business and public sector organisations to engage with CTA, including procurement procedures and industry activities, no strategic roadmap with industry is in place and no mapping of the relevant regional innovation ecosystem is publicly available. A communication plan has been developed, identifying the communications objectives, stakeholders to be addressed, a communications strategy and themes and key messages. However, the narrative does not include the environmental, social, cultural, economic and political **impacts**. A **Data Management Plan** is in place, including the policy regarding the analysis tools and outputs that will be made available to the principal investigator. After a proprietary period, data will be made openly available through the CTA data archive. Local outreach programmes in the host countries and the outreach infrastructure required to promote communication at government, commercial, and public levels are being implemented. An international convention has been drafted and the **international** outreach and visibility are strengthened by the CTA membership of major Countries outside the EU.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The bottlenecks for the full construction and sustainability of the CTA Observatory are of financial nature. In particular, funds to allow for the completion of the baseline configuration, to guarantee the operations at an effective level and to support upgrade programmes for the instrumentation are still to be ensured. It may be considered that the Members of the ERIC could find further construction funds once the threshold configuration is in place and produces excellent science. At the same time, it is possible that other countries will join as Members or Associates, by contributing with further telescopes. Members contributing to the construction have a legitimate expectation of the return to their scientific communities. A well-defined strategy for attributing observation time and related operation costs needs to be established in view of the Operation Phase. Finally, seed money needs to be sought to lead a coordinated effort for supporting future upgrades.

Recommendations

- Define a business model able to cope with the access costs and upgrading costs.
- Define, validate and keep updated the cost book as a key instrument to pursue firm financial commitment.
- Seek to guarantee the funds for the completion of the (2nd phase) construction as soon as possible.
- Assess and describe the costs and the scientific benefit of each phase of funding.
- Create a socio-economic narrative and indicators to be revised over time.

EISCAT_3D

ENVIRONMENT	
	EISCAT_3D **Next generation European Incoherent Scatter radar system**
The next generation European Incoherent Scatter radar system is a three-dimensional imaging radar for atmospheric and geo-space research, which constitutes an upgrade to EISCAT, an existing international infrastructure based in Europe and devoted to the study of the upper atmosphere, ionosphere and Geospace. EISCAT_3D provides a powerful new Research Infrastructure, using radar observations to explore how the Earth's atmosphere is coupled to space around the planet, as well as providing wider support to solar system and radio astronomy sciences. Using versatile computer technology, it will also help new areas of research, such as micrometeor measurements and asteroid imaging.	

Typology RI	Single-sited
Lead Country	SE
Members	CN, FI, JP, NO, SE, UK
***Observer (ERIC)**	
Prospective Members	
ESFRI Roadmap Entry	2008
ESFRI Landmark	2018

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EISCAT_3D	2005-2009	2.0	2.9	
	EISCAT_USERS_1	2006-2009	0.6	0.6	
	EISCAT_3D_2	2010-2014	4.5	5.9	
	TOT	2005-2014	7.1	9.4	11.1
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EISCAT3D_PfP	2015-2017	3.1	3.1	
	TOT	2015-2017	3.1	3.1	72.2
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	ENVRI	2011-2014	3.7	5.1	
	ENVRI PLUS	2015-2019	14.7	15.0	
	EOSC-hub	2018-2020	30	33.3	
	ENVRI-FAIR	2019-2022	19.0	19.0	
	TOT	2011-2022	67.4	72.4	
Legal Status	EISCAT Scientific Association, 1975				
In Operation since	2020 (Currently in Implementation Phase, ESFRI Landmark)				

Implementation Readiness Level and Future Outlook

EISCAT_3D is an ESFRI Landmark and has been on the roadmap since 2008. It is a major upgrade of the existing infrastructure of the EISCAT Scientific Association, a non-profit legal structure in Sweden that has operated EISCAT for over 35 years. This same structure will be used for the management and governance of the EISCAT_3D. It has been in the Implementation Phase since September 2017 and the first scientific operations are planned for 2022. Accordingly, we have assessed EISCAT_3D as being at **RL4** and consider that EISCAT_3D is on the way to RL5 which could be achieved as soon as the infrastructure is established and the first data and scientific results are produced.

Long-term Sustainability

Access policy will be built on that used in EISCAT and will comprise a mixture of Common Programmes conducted on behalf of the whole user community, Special Programmes carried out by individual groups from Associate and Affiliate countries and Open Programmes proposed by research groups from any Country and selected by peer review. The user community currently numbers a few hundred researchers and scientists mainly from the EISCAT Associates. It is predicted that this number could grow by a factor of 10 when EISCAT_3D is implemented. EISCAT seeks to extend the availability of the systems to scientists from other countries. Although the **business model** is stable, it would be very enriching for the user community if more access days per year at EISCAT could be offered. The infrastructure should provide key high-quality measurements with sufficient additional data (metadata, collaborative measurements, etc.) to remain relevant in a rapidly changing research environment. The **governance structure** is well established with solid stakeholder engagement. Reflection on **KPIs** is ongoing. In order to constantly provide services to match user needs, the Science Advisory Committee (SAC) largely performs the role of a user committee.

The SAC is comprised of representatives from each Associate country and Affiliate organization who provide input to the EISCAT Council, acting, in part, as representatives from the larger user base. The International EISCAT Radar School is a **training** course for new users of incoherent scatter radars at any stage of their research career. The school covers all essential aspects of the current incoherent scatter radar systems, including the science programme. Staff exchange programmes are also under development in order to facilitate the exchange of knowledge among staff working in Research Infrastructures or related to the implementation of new Research Infrastructures. The cooperation between the EISCAT_3D community and other space research and space technology actors in Northernmost Scandinavia, including regional and local authorities has led to the inclusion of space activities in the regional agendas of e.g. smart specialisation. In terms of **impact**, the collaboration on EISCAT_3D will certainly bring benefits to the future users of the system as they will gain access to a world leading and cost-efficient system for studies of the Arctic/sub-Arctic atmosphere and near-Earth space environment. The advanced measurement capabilities of the new system will expand the area of research, and hence also the user community. The new system will be implemented for a wide range of users and applications. It will allow studies to close the gap between space research and environmental research. Concerning the **international outreach**, there are collaborations between the RIs globally to provide a global view of large scale phenomena in the Earth's ionosphere.

Long-term sustainability of EISCAT_3D depends on the issues mentioned above being promptly addressed in order for them not to become real obstacles in the mid-term perspective.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The scientific community in the core EISCAT domain is well and long-established and organised (core community means the institutions of the member countries). Despite its excellent track record, EISCAT indicated some issues which should be addressed in order to ensure the successful transition from the existing to the upgraded infrastructure. These include continuing the discussions on possible new membership (Associate and Affiliate) in the EISCAT Scientific Association and therefore on assuring financial commitments; determining the funding for investment and operating costs and assessing the financial risk of not reaching 100% of the Phase 1 budget (presently secured up to 86%) in timely manner; assessing the risk linked to obtaining building permission in the host countries and corresponding delays in delivering the scientific results and data expected by the users' community.

Recommendations

- Make an operational plan for concurrent operations of the existing EISCAT system and EISCAT_3D with clear funding and staffing.
- Establish and maintain reliable relationships with the funding bodies which will support the research goals of the infrastructure by providing long-term funding commitments.
- Enlarge the user community and increase the number of users as soon as the infrastructure is operational.
- Introduce open access following the EU Charter for Access to Research Infrastructures ensuring guaranteed access for researchers from non-member countries.
- Apply the FAIR data principles to the open access available data produced by the infrastructure.

ELI

PHYSICAL SCIENCES & ENGINEERING

ELI

Extreme Light Infrastructure

The Extreme Light Infrastructure is a Research Infrastructure to probe extreme light-matter interactions at the highest intensities, shortest time scales and broadest spectral range. ELI will provide unprecedented energy and attosecond time resolution of coherent radiation and laser-accelerated particle beams for fundamental studies in atomic, molecular, plasma and nuclear physics to serve a broad European scientific community and a large variety of scientific applications, ranging from biology, chemistry and medicine to astrophysics in the laboratory. It is organised as an integrated organisation with multiple sites, targeting different scientific objectives of the scientific programme, each under direct national responsibility for the construction, and governed and managed jointly in the Operation Phase.

Typology RI	Single-sited
Lead Country	CZ, HU, RO (applicants to the ESFRI Roadmap of the 3-pillar project)
Members	
***Observer (ERIC)**	UK
Prospective Members	CZ, DE, FR, HU, IT, RO
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ELI-PP	2007-2010	6.0	8.0	
	TOT	2007-2010	6.0	8.0	6
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ERDF (contracts with pillar hosting MS for construction)				
	ELITRANS	2015-2019	3.4	3.4	
	IMPULSE	2019-2023	20.0	20.0	
	TOT	2015-2023	23.4	23.4	850

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	CRISP	2011-2014	12.0	15.8
	CREMLIN	2015-2018	1.7	1.7
	EUCALL	2015-2018	7.0	7.4
	ACCELERATE	2016-2020	3.3	3.3
	ARIES	2017-2021	10.0	10.2
	PaNOSC	2018-2022	11.9	11.9
	ERIC Forum	2019-2022	1.5	1.5
	TOT	2015-2022	47.4	51.8
Legal Status	EELI Delivery Consortium AISBL, 2013 (ERIC application)			
In Operation since	2020 (Currently in Construction Phase, ESFRI Landmark)			

Implementation Readiness Level and Future Outlook

ELI entered the ESFRI roadmap in 2006 and has been the first large scale experiment of financing a pan-European RI project completely using parallel national structural funds. The three national pillars are advancing in the Construction Phase. ELI Delivery Consortium achieved the AISBL status in 2013 and ESFRI Landmark status in 2016. At present two out of three of the national Pillars are at the commissioning stage **RL4**, whilst one is behind. The different level of accomplishment of the construction by the three pillars makes the overall infrastructure not homogeneously in line with the expectations at the time it was recognised as ESFRI Landmark. The application for ERIC status was done in 2020 by four EC Countries and one Observer, with and initial two-pillar configuration (RL4) according to readiness for delivering users services.

Long-term Sustainability

While the implementation of the "Extreme Light Infrastructure" ELI is advancing, the overall goal to create a single multi-sited laser user facility of pan-European dimension and the necessary conditions for the future operation are still in progress. The main objectives of the post Preparatory Phase project, ELI-TRANS (ended in 2019), appear to have been only partially reached:

The bilateral nature and separate governance of European Regional Development Funds (ERDF) has led to misalignments in the timeline of the three pillars and lack of commitment by non-Host countries to establish the unifying governance and scientific interface to future users. This has reflected on many aspects of the implementation, especially joint-conflict resolution, stable recruitment of qualified staff, and uniform control of deliverables. The Delivery Consortium (ELI-DC) was created to emphasise the pan-European dimension to the three facilities funded from European Regional development Funds (ERDF), and to coordinate the process towards the ERIC. At present only two pillars (ELI-Beamline and ELI-ALPS) are moving towards full operation and are actually pursuing the creation of the ERIC. Technical issues and legal conflicts are hindering the progress of the third pillar (ELI-NP). The integration of ELI ERIC and its facilities is expected to take place over a 36-month period from the foreseen ERIC establishment. It is planned that during this transition period, ELI-Beamlines and ELI-ALPS will operate together while still being formally separate legal entities The new IMPULSE project is a strong EU contribution (to all three pillars) to accelerate the process towards the establishment of the fully operational research infrastructure, addressing the key issues and appropriate commitments of the members, the full description of financial planning and risks and consolidating a robust, sustainable operation plan.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Overall the establishment of this infrastructure has suffered delays in a number of areas resulting in a number of objectives not being achieved or missed. While the construction of two out of three pillars of ELI is nearing completion, the conditions for operation as a unique multi-site pan-European RI have been difficult to settle. The overall delay in establishing the ultimate configuration of ELI has been due to differences in strategic views of the level of integration of the three facilities in a single organization. This has consequently led to a lack of commitment to operational funding from non-Host countries, to uncertainties in attracting international staff and lack of adequate management control of the overall implementation. Business planning should be used as a vehicle within the implementation of the infrastructures. The priority should be assigned to developing a fully costed operating model, at least for the two more advanced pillars, as a key input to the development of the Business Plan, which will be key to securing future commitments to the foreseen ELI ERIC.

The difficulties in the setting up of this Research Infrastructure, linked to the origins of the construction decisions and funding sources represent a much bigger issue than the HLEG can cover in this report and can advise on. Our statements focus exclusively on the long-term sustainability conditions as represented in the European Commission Staff Working document SWD (2017).

Recommendations

- Exploit for maximum benefit the extra EU funding (IMPULSE) to model a sustainable and effective pan-European infrastructure with an appropriate share of operating costs and clear obligations of members thus realizing the full original science programme.
- Develop the ERIC with greater involvement of the MS/AC that have the largest potential user communities.
- Consolidate the conditions for the successful start of the ERIC with the two advanced pillars and key European partners as well as for the eventual subsequent inclusion of the third pillar. The ERIC context should become attractive for more potential ERIC members
- Enhance collaboration between ELI-ALPS and ELI-BL and with other scientific partners at national (members of LASERLAB EUROPE consortium) and pan-European facilities in order to share people and technologies and to save resources and time.
- Set up a unique user access procedure adopting suitable models and a robust scientific and technical liaison among the pillars as well as with thematically close Research Infrastructures for preliminary or complementary research work by users.
- Set up advanced data and data analysis management based on compliance with EOSC from the start.
- Contribute to international projects that are quickly developing elsewhere as the European centre of competence in extreme light production and advanced light-matter experiments.

EST

PHYSICAL SCIENCES & ENGINEERING	
	EST **European Solar Telescope**
The European Solar Telescope (EST) is a project aimed at designing, constructing and operating a 4-metre class solar telescope dedicated to the study of the fundamental processes in the Sun that control the solar atmosphere and its activity and the physical conditions in the heliosphere. EST is an initiative of the European Association for Solar Telescopes (EAST), coordinated by the Instituto de Astrofísica de Canarias.	

Typology RI	Single-sited				
Lead Country	ES				
Members					
***Observer (ERIC)**					
Prospective Members	ES, SE, UK				
ESFRI Roadmap Entry	2016				
ESFRI Landmark					
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EST	2008-2011	3.2	6.8	
	GREST	2015-2018	3.0	4.0	
	PRE-EST	2017-2021	4.0	9.0	
	TOT	2008-2021	10.2	19.8	21

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				200
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	SOLARNET FP7	2013-2017	6.0	8.2	
	SOLARNET H2020	2019-2022	10.0	13.5	
	TOT	2013-2022	16.0	21.7	
Legal Status	Pending				
In Operation since	Foreseen 2029 (Currently in Preparation Phase, ESFRI Project)				

Implementation Readiness Level and Future Outlook

EST has been on the ESFRI Roadmap since 2016. Proposed and supported by 3 MSs, EST was developed with two design studies and through the Solarnet Integration Actions (FP7+H2020). EST will enter the Implementation Phase in 2021. First light is planned for 2027. Currently preparatory work is done under PRE-EST Preparatory Phase H2020 grant, completing the technical design, consortium and implementation plan and first tenders for equipment (deformable mirrors). The EST Project Office has been successfully set up with a dedicated team of 24 people. A Science Advisory Group defines the final scientific requirements for EST. Siting evaluation is underway between Tenerife and La Palma islands of Canarias, both currently hosting solar towers and large telescopes. An overall costing and financial timeline has been sketched out. The EST Consortium's goal is to complete the construction plan within the next three years, right after the end of the Preparatory Phase. An interim legal structure is being considered before addressing the ERIC. EST is assessed as being at **RL2**. Progress to RL3 will depend on designing the legal structure and consortium of the RI.

Long-term Sustainability

The sustainability of the Construction Phase is not yet achieved. European and international partnerships are expected to converge towards adequate contributions for construction. **Scientific excellence** could be strengthened by **internationalisation**, which would further improve attractiveness as well as **innovation potential**. Reaching the critical MS/AC commitment to a construction budget and cash-flow and to 30-year of operation of the EST implies as a **framework condition** a plan of operation and/or reorientation of scope or termination of the current suite of solar telescopes in the Canaries, properly phased with the EST construction and operation start-up. Several elements for the LTS of EST need to be built into the technical design and management structure, including the access policy, the policies relating to the services that EST will deliver, and internationalisation. Co-creation with industry in the Construction Phase and the potential for selling commercially valuable observations (to space and aerospace operators) should be elements of the business plan contributing to the 30-year sustainability goal. A continuously updated cost book and a scheme for a means of optimising in-kind contributions are also needed as a building block of the consortium. The analysis of **socio-economic impact** on the Canaries has been sketched out and must become an acknowledged regional policy strategy document with quantitative figures.

Major Bottlenecks and Possible Measures Which Might impact Further Development

National roadmap prioritisation is still missing for most of the 18 MS/AC partners of the European Association for Solar Telescopes (EAST). The main bottleneck of the project is to reach the critical mass of funding. To this end, setting up an EST board of governmental representatives is an urgent priority as well as developing a consortium for assuring coverage of the 10-year construction and early operation costs, adopting a legal form, and deciding the construction site. A firm timeframe of construction must be fixed, both in terms of adoption of a given technical design of the main infrastructure and suite of first light experimental facilities. The slow public procurement process of systems and subsystems for the construction of ETS could result in bottlenecks for the project.

Recommendations

- All EAST members should proactively work for national prioritisation of the EST and for the optimisation of resources in the relevant timeline of all the solar Research Infrastructures.
- EST should carry out a user survey.
- EST should produce a robust, third-party validated cost book and cash flow analysis for reducing risk in the Government decisions to finance.
- EST should explore internationalisation options with possible impact on design.
- EST should take advantage of the long tradition of advanced data management and open access to data developed by astronomers to participate to the EOSC initiatives, also foreseeing services well suited to open science and citizen science.

EUROPEAN SPALLATION SOURCE ERIC

PHYSICAL SCIENCES & ENGINEERING	
EUROPEAN SPALLATION SOURCE	**European Spallation Source ERIC**
The European Spallation Source ERIC (ESS) has the aim of building and operating the world's most powerful neutron source for research, enabling scientific breakthroughs in materials, energy, health and the environment, and addressing important societal challenges. The construction of the facility is 64% complete. The facility is being built in Lund (Sweden), while the ESS Data Management and Software Centre (DMSC) is based in Copenhagen (Denmark). A set of 15 instruments (out of 22 anticipated public instruments in the long term) will be built during the Construction Phase. First Science is scheduled for 2023. The user programme will enable an estimated two to three thousand visiting scientists to perform experiments each year at ESS during Steady State Operations. Users are expected from European academic and research institutions as well as from industry.	

Typology RI	Single-sited
Lead Country	SE (facility in Lund) DK (Data Management and Software Centre in Copenhagen)
Members	CH, CZ, DE, DK, EE, ES, FR, HU, IT, NO, PL, SE, UK
***Observer (ERIC)**	NL
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	NEUTRONS OURCEESS	2008-2010	5.0	6.6	
	TOT	2008-2010	5.0	6.6	80
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	BrightnESS	2015-2018	20.0	20.0	
	BrightnESS-2	2019-2021	5.0	5.1	
	TOT	2015-2021	25.0	25.1	654

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	CRISP	2011-2014	12.0	15.8
	EUCARD-2	2013-2017	8.0	23.4
	CREMLIN	2015-2018	1.7	1.7
	iNEXT	2015-2019	10.0	10.0
	SINE2020	2015-2019	10.9	12.1
	SoNDe	2016-2019	3.8	3.8
	ACCELERATE	2016-2020	3.3	3.3
	EOSCPILOT	2017-2019	10.0	10.0
	ARIES	2017-2021	10.0	10.2
	RAMP	2017-2021	3.2	3.2
	ESSnuSB	2018-2021	3.0	4.7
	PaNOSC	2018-2022	12.0	12.0
	ERIC Forum	2019-2022	1.5	1.5
	TOT	2009-2022	89.4	111.7
Legal Status	ERIC, since 2015			
In Operation since	Foreseen 2026 (Currently in Construction Phase, ESFRI Landmark)			

Implementation Readiness Level and Future Outlook ESS has been on the ESFRI Roadmap since 2006 and became a Landmark in 2016. ESS is a large-scale Research Infrastructure project involving about EUR 2 Billion of investment carried out by the MS and AC members, with a large construction share being provided by the Host Countries, SE and DK. It has been an ERIC since 2015, currently involving 13 MSs and ACs as Members. The well-advanced construction and European/global reference role for the future of neutron science led to ESS the status of ESFRI Landmark. A one-off substantial EC support has contributed to the development of the In-Kind Contribution management model and of innovative solutions to detector technology challenges. Currently, the ESS is assessed at **RL4**. Although the construction is 64% complete (as of January 2020), ESS is several years away from Steady State Operations and first access by users that would represent RL5.
Long-term Sustainability The financing of the Construction Phase has been officially secured. The construction budget includes EUR 1843M as defined in the Statutes plus “additional construction costs” of EUR 135M approved by the ESS Council in 2019. The overall construction cost had increased due to uprated seismic and security standards adopted globally in the aftermath of the Fukushima accident. The ESS Council has also committed to cover the Initial Operations costs of EUR 810M and agreed on the 2020 budget. The delivering of the first user access has been postponed and First Science is anticipated in 2023. Although this is a common shortcoming of large installations, it nevertheless represents a challenge towards sustainability as the ERIC must address both the Operations budget and the higher cost of construction. At this stage, the project is planning on an initial beam power of 2MW, which is lower than the 5MW in the science case, to be reached later. Another risk is the delay of the second batch of instrumentation which in turn could delay the full deployment of the science return vs. Operations cost. The sustainability preconditions of **scientific excellence** will be met, provided the full performance of the project is reached in terms of power and instruments. Attracting **managers and staff** has been successfully achieved, but with a high impact on the running budget. **Innovation** and **socio-economic impact** are addressed both for the Host Countries and for those providing In-Kind Contributions (e.g. ESS Bilbao). ESS plays an active role in defining **data management** best practices and contributes to the development of the EOSC. It appears that the operations budget needs to be negotiated by the ERIC Members to move towards the RL5 Operations stage. Sustainability could be assessed on the basis of the outcomes of this ongoing process. Internationalisation can bring advantages on most preconditions.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Some serious bottlenecks are related to legal limitations of the ERIC framework, i.e. not fully addressable by the ESS alone. Examples include the lack of clarity on the VAT regime for In-Kind Contributions to the ERIC, and the compatibility of the ERIC with international partners outside the EU. Specific bottlenecks have to do with the planning of the instrument suite, both quantitatively and qualitatively. The first set of ESS instruments will be state of the art even at a reduced accelerator power of 2 MW, this must not detract from the pressure of the scientific community on national authorities to keep increasing the effort towards full implementation of the ESS. The future obsolescence of current nuclear reactor sources presents a risk for the neutron scattering community, which may suffer from limited access to neutron facilities before the ESS enters Steady State Operations and consequently shrink. This issue may also imply new investments in novel, regional sources, creating further strain on the overall financial exposure of MS/AC in neutron science.

The budget negotiations need to avoid solutions that would actually limit the full deployment of the ESS, or retard its construction and Steady State Operations. This may imply revision of the overall running costs. Internationalisation is one avenue to long-term robustness of the ESS, but it implies the need to reach full design goals and operate at full capacity.

Recommendations

- Actively engage the European scientific community by creating conditions for participation in science programmes and innovative instrumentation at ESS.
- Attempt to agree on sustainable Operations costs with ERIC Members, while aiming to reach full capacity of the facility.
- Create conditions for substantial contributions from global partners.
- Contribute to the sustainability of the whole neutron scattering community, the expansion of neutron techniques to new scientific disciplines, and the usage of data (through EOSC) by participating in a well-balanced overall renewal plan for neutron landscape in Europe.

FAIR

PHYSICAL SCIENCES & ENGINEERING	
	FAIR **Facility for Antiproton and Ion Research**
FAIR will provide high energy primary and secondary beams of ions of highest intensity and quality, including an “antimatter beam” of antiprotons allowing forefront research in nuclear structure physics and nuclear astrophysics with radioactive ion beams, QCD studies with cooled beams of anti-protons, physics of hadronic matter at highest baryon density, plasma physics at very high pressure, density and temperature and atomic physics and applied sciences. The accelerator facility foresees the broad implementation of ion storage/cooler rings and of in-ring experimentation with internal targets. A fast cycling superconducting synchrotron will deliver high intensity ion beams up to 11 GeV per nucleon for experiments with primary beams of ion masses up to Uranium and the production of a broad range of radioactive ion beams.	

Typology RI	Single-sited
Lead Country	DE
Members	DE, FI, FR, IN, PL, RO, RU, SE, SI, UK
***Observer (ERIC)**	
Prospective Members	CZ
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	DIRACSECONDARY-BEAMS	2005-2009	9.0	17.0	
	DIRAC-PHASE-1	2005-2011	10.4	101.0	
	FAIR	2007-2012	4.9	5.4	
	TOT	2005-2012	13.9	22.4	NA
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				1261
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ENSAR	2010-2014	8.0	11.2	
	CRISP	2011-2014	12.0	15.8	
	CREMLIN	2015-2018	1.7	1.7	
	ENSAR2	2016-2020	10.0	10.0	
	ESCAPE	2019-2022	16.0	16.0	
	TOT	2011-2022	47.7	54.7	
Legal Status	GmbH, since 2010				
In Operation since	Foreseen 2025 (Currently in Implementation Phase, ESFRI Landmark)				

Implementation Readiness Level and Future Outlook FAIR is an ESFRI Landmark that has been on the roadmap since 2006 and was incorporated as a GmbH in Germany in 2010. In total over fifty Countries are involved in the FAIR science programme by contributing to the construction and to the exploitation of the FAIR experiments. FAIR is currently under construction adjacent to the GSI facility in Darmstadt, Germany. It will use the upgraded GSI accelerators as injector chain. FAIR has benefited from significant EU funding for R&D and prototyping from 2005-2011 covering Injector (Synchrotron) Upgrades at GSI, Beam Storage Rings and Cooling, Target Development, LINAC Development, Magnets and for the detector developments for the Nuclear and Hadron Physics science communities in Europe totalling some EUR 44 million. Although experiments with FAIR detectors at the existing GSI accelerators and FAIR equipment started in 2018 (the FAIR Phase-0 programme), we have assessed it as being at **RL4**. Commissioning is planned for 2025 following which FAIR can be expected to move to RL5.
Long-term Sustainability Given the close relationship and dependency between FAIR and GSI it is reasonable to assume that FAIR will share many of the sustainability preconditions that GSI demonstrates. While in some respects FAIR does explicitly demonstrate compliance with the prerequisites (**governance, attracting and training staff** and a commitment to **scientific excellence**) there are many areas (e.g. **access policy** and **data** access and management policy) where FAIR specific information is difficult to find, although one assumes they are done in synergy with GSI. The FAIR website points often back to GSI, which can be understood as a local policy, but makes it hard to identify the specific FAIR solutions, if any. Regarding **scientific excellence**, the Nuclear Physics European Collaboration Committee (NuPECC) regards FAIR as the top priority in nuclear physics in Europe and that “FAIR is a European flagship facility for the coming decades. Regarding **international outreach**, ESFRI suggested in 2016 to structure a scientific collaboration with other RIs in the field of accelerator based nuclear physics, namely NICA and SPIRAL-2. FAIR has actively pursued this with collaborations with both projects in place.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Despite strong support for FAIR from the shareholders at ministry or funding agency level, funding for the construction of the facility as designed remains a challenge. The baseline cost of construction based on 2005 prices is EUR 1.262 billion. The FAIR Council initiated a high-level international review of the FAIR project (completed in Spring 2019), which estimated the total additional cost as EUR 850M (current prices) but recommended completion of the full project at the new price. This would involve seeking significant additional funding from existing and new partners. DE is making a lead effort and discussion with the partners is currently underway. Importantly, these discussions include not only the construction cost but also contingency, early operations and maintenance and full operations.

The focus of attention for FAIR at the moment is on securing full construction funding. Once this is achieved, possibly by a combination of new funding, partial descoping and delayed schedule, attention will turn to operations funding, which will become the key issue for future sustainability.

It is clear that EU funding has been important in getting FAIR altogether to its current level and it is expected that this support will continue in the future. Any lack of this continued EU funding would represent a further bottleneck, but there is a risk of overreliance on EU funding.

In common with many large projects of this type, FAIR is proposed to be constructed with a high level of in-kind contribution. The high-level review noted that given this 'the FAIR management can never be expected to be in complete control.' It requires the partners to honour their obligations in delivering equipment in a timely manner in order not to affect the Project progress. Inability to do this can put other areas of the Project in jeopardy. Unfortunately, there is evidence of that already happening which, if not corrected, will have an adverse effect on the Project schedule and final cost'. This is very likely to be a future bottleneck and one which the FAIR Council will need to pay special attention to.

Recommendations

- The FAIR webpages point back to the GSI website for key information. Information on user access, open data access and other policies should be specifically addressed on the FAIR website, otherwise the image given is that of a national RI with international scope rather that a pan-European RI.

- Construction costs should be revised, preferably based on current or re-baselined prices and should include contingency and spares, and properly communicated.

- In parallel with the current funding discussions with existing and potential future partners, FAIR management need to explore and confirm the future funding prospect with the EU.

KM3NeT 2.0

PHYSICAL SCIENCES & ENGINEERING

KM3NeT 2.0

Neutrino Telescope 2.0

KM3NeT 2.0 is a Research Infrastructure housing the next generation neutrino telescopes. Once completed, the telescopes will have detector volumes between megaton and several cubic kilometres of clear sea water. Located in the deepest seas of the Mediterranean, KM3NeT 2.0 will open a new window on our Universe, but will also contribute to the research of the properties of the elusive neutrino particles. With the ARCA telescope, KM3NeT 2.0 scientists will search for neutrinos from distant astrophysical sources such as supernovae, gamma ray bursts or colliding stars. The ORCA telescope is the instrument for KM3NeT 2.0 scientists studying neutrino properties exploiting neutrinos generated in the Earth's atmosphere. Arrays of thousands of optical sensors will detect the faint light in the deep sea from charged particles originating from collisions of the neutrinos and the Earth.

Typology RI	Single-sited
Lead Country	NL
Members	
***Observer (ERIC)**	
Prospective Members	EL, FR, IT, NL
ESFRI Roadmap Entry	2006, 2016
ESFRI Landmark	

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	KM3NET-PP	2008-2012	5.0	13.0	
	KM3NeT-INFRADEV	2017-2020	3.8	3.8	
	TOT	2008-2020	8.8	16.8	45
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				151
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries.	ASTERICS	2015-2019	15.0	15.0	
For the rationale of presenting these figures, please go to page 71.	ESCAPE	2019-2022	16.0	16.0	
	TOT	2015-2022	31.0	31.0	
Legal Status	Pending				
In Operation since	Foreseen 2020 (Currently in Construction Phase, ESFRI Project)				

Implementation Readiness Level and Future Outlook

The current KM3NeT 2.0 Collaboration comprises more than 250 scientists from fifteen Countries including several outside Europe, and fifty-three institutes. Its modus operandi is defined in a Memorandum of Understanding. In the future, it aims at establishing an ERIC. It entered the ESFRI roadmap in 2006, and again in 2016 as a deeply revised 2.0 RI project. KM3NeT 2.0 is assessed at **RL3**. Progress towards RL4 requires establishing a legal status.

Long-term Sustainability

KM3NeT 2.0 has passed through two Preparatory Phases and as such the investment already provided by the European Commission is not negligible. A TDR has been performed and scientific publications have been presented, which indicate that the RI has **scientific excellence** and **impact.** However, the user access policy is not publicly available yet, which would increase the RI's visibility. An Outreach and Communication Committee is in place that is expected to take a lead on the development and execution of the Outreach and Communication plan, in close collaboration with the management and the KM3NeT 2.0 Institute Board. The use of the KM3NeT 2.0 **data** by external scientists requires training, e.g. on the design and functionality of the instrument, the simulation procedures and the event reconstruction algorithms. This training is expected to be provided through a virtual educational centre. A Technology and **Innovation** Panel has been setup with the mandate to liaise with the various KM3NeT 2.0 labs and working groups. KM3NeT 2.0 has identified possible innovative technologies but no mapping of the innovation ecosystem is publicly available, although the construction of the infrastructure fits well with the Smart Specialisation Strategies of the host countries and nationally-managed structural funds were awarded for contributing to the construction. There is a narrative in place regarding environmental **impact**. However, there are no **socio-economic** indicators so that should be sought during the execution of the 2nd Preparatory Phase. There is a design of an Open Access policy. A **Data** Management Plan is in place also mentioning a willingness to adhere to the FAIR principles and integrate the generated data in the EOSC. The amount of data expected to be generated by KM3NeT 2.0 is large, so resources have been allocated already, but access to storage and computing resources must be further secured during the Preparation Phase. For a Research Infrastructure of the size and complexity of KM3NeT 2.0 a legal entity is urgently required. The Consortium aspires to establish an ERIC, which will allow streamlined procurement of components. However, it is still not fully clear how the current project structure would map onto an ERIC structure or how the transition would be achieved. Presently the construction funds originate mainly from France, Italy and the Netherlands, although the consortium is composed of scientists from 15 countries including several outside Europe. The imbalance between hosting countries and participating countries could generate difficulties in the governance and in the coverage of the operational costs. Although many different outreach channels have been used to promote KM3NeT 2.0 to the general public, no information is available regarding **international** outreach. However, some of the countries in the consortium are outside the EU, for example, South Africa, implying that some international outreach is happening.

Major Bottlenecks and Possible Measures Which Might impact Further Development To match the funding profile, a phased implementation of the Research Infrastructure has been adopted. KM3NeT 2.0 has presently secured approximately 30% of the required budget to complete the project and has solved almost all technical problems concerning the detector design and deployment at sea. Following the successful deployment and operation of a series of prototypes, the construction of the Phase-1 of the KM3NeT 2.0 is in progress at the sites in Italy and France. Funding for Phase-2 is now critical in order not to retard and reduce effectiveness of the investment done until now.
Recommendations • Advance towards ERIC status to solve the imbalance on funds between hosting countries and participating countries. • Explore all possible synergies for such a costly installation and maintenance of data communication and power supply equipment at the marine floor. • Work to reflect the APPEC roadmap in national roadmaps, in synergy with other initiatives in the area of neutrino research. • Expand, enhance and showcase contracts with industry, which are already visible and which have produced interesting results.

SKA

PHYSICAL SCIENCES & ENGINEERING	
	SKA Square Kilometre Array
The Square Kilometre Array (SKA) is a global effort to build the largest radio telescope facility on Earth. SKA, being located in two optimal sites for low EM background in the Southern Hemisphere, will be able to look back into the furthest reaches of the cosmos to study the first structures in the Universe, helping to understand some of the most fundamental questions in physics, as well as probing the nature of gravity and cosmic magnetism and exploring the origins of life itself. The extremely large array of antennas will determine an unprecedented volume and rate of data production and communication that require the development of all-new standards, that will foster expectedly the developments of a new generation of technologies in data handling and transmission.	

Typology RI	Single-sited
Lead Country	SKAO
Members	AU, CA, CN, DE, ES, FR, IN, IT, NL, NZ, SE, UK, ZA
***Observer (ERIC)**	
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	SKADS	2005-2009	10.4	28.6	
	PREPSKA	2008-2012	5.5	35.5	
	GO-SKA	2011-2015	0.9	1.2	
	TOT	2005-2015	16.8	65.3	NA
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	IN-SKA	2016-2018	5.0	5.0	
	TOT	2016-2018	5.0	5.0	674
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	CRISP	2011-2014	12.0	15.8	
	ASTERICS	2015-2019	15.0	15.0	
	ESCAPE	2019-2022	16.0	16.0	
	TOT	2011-2022	43.0	46.8	
Legal Status	SKAO, 2011; Convention establishing SKA Observatory as Intergovernmental				
In Operation since	Foreseen 2027 (Currently in Construction Phase, ESFRI Landmark)				

Implementation Readiness Level and Future Outlook

SKA entered the ESFRI roadmap in 2006 and achieved the Landmark status in the ESFRI Roadmap 2016. It is currently in the Implementation Phase. SKA is at the moment transitioning from the SKA-Organisation – a private, non-profit company which has overseen the telescope design phase – into the SKA-Observatory. The Observatory will be the legal entity responsible for constructing and operating the SKA telescopes in Australia and South Africa, with its headquarters in the United Kingdom. The text of the SKA Observatory Convention was agreed in May 2018 and signed on 12 March 2019 in Rome. Seven countries became the initial signatories to the Convention: Australia, China, Italy, the Netherlands, Portugal, South Africa and the United Kingdom. The Convention stipulates that the SKA Observatory will enter into force once five signatories have ratified the text, including all three host countries: Australia, South Africa and the United Kingdom. Construction is planned to start in 2021, preceded by the first SKA Council meeting in June 2020. Work to finalise the policies and procedures necessary for the IGO is being undertaken by a preparatory task force of the Convention signatory governments. Clear synergies are established with the RIs NenuFAR, LOFAR, GMRT and many others, as well as with the SKA Precursor telescopes in South Africa (MeerKAT and HERA), and Australia (ASKAP and MWA). Synergies with the RIs concurring in the multi-messenger astronomy are exploited. Accordingly, SKA is assessed SKA as being at **RL4**. Initial operation is planned for 2027 that will correspond to achieving RL5.

Long-term Sustainability

"**Scientific Excellence** driven access mode" is an important principle of the access policy of the SKA infrastructure. In first instance access is reserved for Member States, with underpinning principles of scientific excellence and balanced return. In addition to that, a certain level of Open Time will be offered with scientific excellence as the driving criterion. Standardized, effective and robust evaluation procedures of the infrastructure through independent international peer-review will be put in place. SKA is conducting investments in developing the required skills through dedicated **Human Capacity** Development Programmes. For example, in South Africa, more than 700 people, ranging from artisans to postgraduate students and postdoctoral fellows, have received support from the project since 2010. This is causing an interest in studying mathematics, engineering and astrophysics at local universities, and attracting top students and academics from around the world to South Africa. The SKA project has developed a strong communication strategy, including culture and heritage, training of the young generation and working with the local communities. SKA is an international project which illustrates both the direct and indirect **socio-economic impact** of investment in RI: technological innovation, industrial development, knowledge and education. The astrophysics community is a pioneer in the field of **data management and open data**. SKA will generate data at a rate more than 10 times today's global Internet traffic. Via its participation in ASTERICS, a H2020 project "Astronomy ESFRI & Research Infrastructure Cluster", substantial progress will be made towards enabling interoperability and software re-use for the data generation, integration and analysis of the ASTERICS ESFRI and pathfinder facilities. ASTERICS has started the creation of an **open innovation** environment for establishing open standards and software libraries for multi-wavelength/multi-messenger data. ASTERICS is also developing common solutions for streaming data processing and extremely large databases, as well as studying advanced analysis algorithms and software frameworks for data processing and quality control. In the construction and operation of SKA infrastructure, **industrial partners** play the role of co-developers, users and suppliers. SKA is looking for an innovative business model and innovative modes of interactions with the industrial partners. The SKA-Consortia in South Africa and Australia have realized a very significant progress, laying down the grounds for the construction of SKA and giving this project the best chances for success. Despite the huge geographical distance between the sites and the headquarters, a unique team spirit has been maintained. Due to the large-scale nature of this Research Infrastructure project, the realisation of the financial issues including financial commitment for construction (>1.5 EUR billion) took both a long time and the involvement of high level government participation.

Major Bottlenecks and Possible Measures Which Might impact Further Development

According to the current project plan, construction of SKA Phase-1 will start in January 2021, once the IGO has been established, its Council formed, and once that Council has been able to approve the construction proposal that is being finalized at the conclusion of the current design phase. Following three years of effort of the international consortia to arrive at the conclusion of the Critical Design Reviews (CDR), an important milestone has just been achieved (December 2019) with the System Critical Design Review, which has just been passed. This was one of the last and most pivotal stages before construction can begin, where In the CDR, the design documentation for each part of the SKA was analysed in detail by external globally-renowned experts, and determinations were made about the readiness of each area of the project. Although the project is progressing, it has suffered from delay, as initially the start of construction and the delivery of the first science were scheduled for 2018 and 2020 respectively. The main bottleneck is to continue the discussions with the countries to support the financing of the SKA construction and ensure that the full planned scope of the instrument is realised. The detailed costs and funding models for completing the Construction Phase need to be defined and secured.

Recommendations

- Consolidate the CDR with an independently validated cost-book and options for partnership for co- creation with industry on a well-defined timeline with milestones.
- Consolidate the financial engagement to cover the full RI construction and operation costs.
- Further enhance the communication effort on progress in technology and socio-economic impacts of the subsequent stages in construction.
- Coordinate the optimization of multi-messenger astronomy with other RIs.
- Communicate broadly the science-diplomacy effects of SKA as a global infrastructure.

SPIRAL2

PHYSICAL SCIENCES & ENGINEERING	
laboratoire commun CEA/DRF CNRS/IN2P3	**SPIRAL2** **Second-generation System On-Line Production of Radioactive Ions**
SPIRAL2 is an expansion of the SPIRAL facility at GANIL (National Large Heavy Ion Accelerator), in Caen, France, which will help maintain European leadership in ISOL (Isotope Separation On Line) development. The Linear Accelerator at the heart of SPIRAL2 will accelerate particles to produce the high-energy beams that will be sent to two new experimental areas. NFS (Neutrons For Science) will be used to study the reactions brought about by fast neutrons in next-generation nuclear reactors, as well as the effects of neutron irradiation in the fields of healthcare and materials. S3 (Super Separator Spectrometer) will use beams of heavy ions to generate and study the exotic nuclei produced in nuclear fusion reactions.	

Typology RI	Single-sited				
Lead Country	FR				
Members	FR				
***Observer (ERIC)**					
Prospective Members					
ESFRI Roadmap Entry	2006				
ESFRI Landmark	2016				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	SPIRAL2PP	2007-2012	3.9	8.8	
	TOT	2007-2012	3.9	8.8	3.9

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	IDEAAL	2017-2020	3.9	3.9	
	TOT	2017-2020	3.9	3.9	266
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	ENSAR	2010-2014	8.0	11.2	
	CRISP	2011-2019	12.0	15.8	
	ENSAR2	2016-2020	10.0	10.0	
	TOT	2010-2020	30.0	37.0	
Legal Status	37.0				
In Operation since	Foreseen 2019 (Currently in Construction Phase, ESFRI Landmark)				

Implementation Readiness Level and Future Outlook

SPIRAL2 is a single-sited Research Infrastructure and an ESFRI Landmark starting commissioning and operation. Part of the well-established GANIL, SPIRAL2 is an extension of the facility which started in 2001 (SPIRAL). France is the only country participating in this RI, although SPIRAL2 has been on the Roadmap since 2006. Since 2016 the GANIL legal status has allowed associated scientific partnerships with national and international collaborating institutions. Contributions for the construction of SPIRAL2 came both in-kind and in-cash. Nevertheless, today SPIRAL2 is not pan-European in its governance, from this point of view it is at RL2. Nevertheless, it is partially operational and completing its construction programme, and definitely having an impact on European science.

Long-term Sustainability

SPIRAL2 is being built to **ensure scientific excellence** in terms of instrumentation and services in relation to scientific and technical developments. It will open a wide range of physics experiments not accessible today, will contribute to several areas of active research in nuclear astrophysics, and will offer opportunities for material irradiations and cross-section measurements. Given the emphasis on scientific instrumentation, already at the Preparatory Phase SPIRAL2 attracted new partners leading to **international** bilateral agreements with USA, India and China. Being part of a long-standing research facility all required user practices are in place and being further optimised. For such complex Research Infrastructures as GANIL with both SPIRAL and SPIRAL2 facilities, focus on **attracting and training the users, managers, and operators** is crucial. The GANIL e-learning platform for external experimenters is available online and as part of the IDEAAL project the exchange and training of personnel with associated partners is being developed. Trans-national access to GANIL is supported through the ENSAR2 project until August 2020, allowing a reimbursement of travel and living expenses of users. Part of the GANIL user community is industrial, but recently the time provided for it has been reduced due to limited access time. The **innovations** and applications with heavy-ion beams are developed and monitored in the framework of ENSAR2 and IDEAAL projects, and R&D dedicated to new radioisotopes for medicine benefit from the REPARE project funded by the French ANR. Potential for **socio-economic impacts** is supported by educational activities, e.g. visits of the labs for teachers, pupils, general public and available pedagogical tools, and could further arise from applications, e.g. production of isotopes for nuclear medicine, and study of the impact of neutrons on materials and living organisms. Aspects on the use of metadata were addressed during the CRISP project but more effort is needed to further explore how to use better the **generated data**, also opening to other communities. **Governance and sustainable long-term funding** for SPIRAL2 depends on it being part of the well-established GANIL and builds on 20 Memoranda of Understanding and collaboration agreements.

Major Bottlenecks and Possible Measures Which Might impact Further Development

SPIRAL2 presents as a national RI with MoUs with other European laboratories and universities and collaboration agreements beyond the EU. In building SPIRAL2, GANIL benefitted from the EC funding thus complementing the baseline national funding. Having built one part of SPIRAL2 it is not clear if sufficient funding is available to cover full construction costs, representing a bottleneck. The shortage of highly qualified human resources for construction of complex accelerator systems is currently a bottleneck for SPIRAL2 and similar facilities.

Recommendations

- A definitive set-up of SPIRAL2 as a structurally national infrastructure with high international impact and collaborations should be adopted, unless clear moves towards a European/international governance are made.

- Evaluate an opportunity of a common science policy with FAIR which might lead to structural collaboration building on the current regular meetings and discussions about ongoing collaborations and future opportunities.

- Make updated and more transparent access policies, rules and/or guidelines publicly available on the GANIL website without a need to create a personalised account. Make it easier for users to get the needed information. Ensure that access policies are in line with EU rules and ensure an excellence based access mode.

- Initiate cooperation with PaNOSC project to work on data access and management policies in line with FAIR principles and the developments of EOSC, implementing the results of ESCAPE. Although the specifics of science are different, the size and missions of the Big Science infrastructures make this collaboration sensible.

- Disseminate and communicate widely examples of socio-economic impacts from the ENSAR2 report (having the report published does not equal wide dissemination). Organise open days more frequently, e.g. once a year instead of currently every two years.

DISTRIBUTED RESEARCH INFRASTRUCTURES

ACTRIS

ENVIRONMENT	
ACTRIS	**ACTRIS** **Aerosol, Clouds and Trace Gases Research Infrastructure**
ACTRIS is composed of observational platforms, exploratory platforms, instrument calibration centres (Topical Centres), a Data Centre and a Head Office. ACTRIS serves a vast community of users working on atmospheric research, climate and Earth system and air quality models, satellite retrievals, weather analysis and forecast systems by offering high-quality data and Research Infrastructure services for atmospheric aerosols, clouds, and trace gases.	

Typology RI	Distributed				
Lead Country	FI				
Members					
***Observer (ERIC)**					
Prospective Members	AT, BE, BG, CH, CY, CZ, EL, ES, FI, FR, IT, NL, NO, PL, RO, UK				
ESFRI Roadmap Entry	2016				
ESFRI Landmark					
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ACTRIS PPP	2017-2019	4.0	4.0	
	TOT	2017-2019	4.0	4.0	6

<table>
<tr><td rowspan="3">Implementation/ Construction</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>ACTRIS IMP</td><td>2020-2023</td><td>5.0</td><td>5.0</td><td></td></tr>
<tr><td>TOT</td><td>2020-2023</td><td>5.0</td><td>5.0</td><td>190</td></tr>
<tr><td rowspan="5">Collaborative Grants

Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td colspan="2">EUR M (Total)</td></tr>
<tr><td>ENVRI</td><td>2011-2014</td><td>3.7</td><td colspan="2">5.1</td></tr>
<tr><td>ENVRI PLUS</td><td>2015-2019</td><td>14.7</td><td colspan="2">15.0</td></tr>
<tr><td>ENVRI-FAIR</td><td>2019-2022</td><td>19.0</td><td colspan="2">19.0</td></tr>
<tr><td>TOT</td><td>2011-2022</td><td>37.4</td><td colspan="2">39.1</td></tr>
<tr><td>Legal Status</td><td colspan="5">Pending</td></tr>
<tr><td>In Operation since</td><td colspan="5">Foreseen 2025 (Currently in Preparatory Phase, ESFRI Project)</td></tr>
</table>

Implementation Readiness Level and Future Outlook

ACTRIS was submitted by the Finnish ESFRI delegation in 2015, with twenty-one participating countries as ACTRIS partners for the ESFRI roadmap. By December 2015, five countries (FI, FR, IT, CZ, RO) had already expressed their financial commitment and political support, an additional seven countries had provided political support, and altogether eighty-five research performing organisations had committed their resources to the implementation of ACTRIS. ACTRIS was adopted on the ESFRI roadmap in 2016. ACTRIS entered the Preparation Phase in 2017 and the Implementation Phase is starting in 2020 (2020-2024) including both construction and commissioning. ACTRIS submitted the ERIC Step 1 application in March 2019 and is aiming to become an ERIC in mid-2021. Following the Implementation Phase, ACTRIS is foreseen to be fully operational in 2025. ACTRIS is assessed at **RL3**. Progress to RL4 requires the establishment of the ERIC and that innovation funding issues are addressed.

Long-term Sustainability

The Interim ACTRIS Council (IAC) and Scientific and Implementation Advisory Board (SIAB), established as part of the ACTRIS PPP, have contributed to setting up the user access and publishing policies as well as clearly defined the **excellent science** requirements. The next expected step is the definition of the scientific KPIs and their monitoring and updating throughout the Implementation Phase. ACTRIS is maintaining a very active **training** and education programme directed towards both European and international scientists. ACTRIS has organised a tailored training for ACTRIS staff members, a training on strategy and leadership for 25 managers. ACTRIS has also set up the transnational access programme to 11 National Facilities and has increased the mobility of the researchers involved. Although the already available services of ACTRIS are being used by industry, business and the public sector and an **Innovation** Platform has been established, ACTRIS still needs to put the ensemble of these activities as a central part of the RI governance structure. Technology transfer and innovation actions require special expertise that needs to be hired by the Research Infrastructure and supported in order to unlock the full innovation potential. Although there is clearly an **impact** from ACTRIS activities in the environmental research arena, the criteria to define social, cultural, economic and political impact are not established yet, though the **socio-economic** and environmental narrative is present. ACTRIS started the systematic work to investigate the methodology for measuring the socio-economic impact by performing studies on direct and indirect impacts. ACTRIS plans to have regular socio-economic impact analyses every 4-5 years. The platform for user access via one single entry point is partially operational and under development and testing (physical and remote access). ACTRIS has established a **data policy,** access and services policy, and is currently working on updating its Data Management Plan. The operational aspects of managing ACTRIS data across all National Facilities and having the data accessible from everywhere are implemented. The next expected step is to make the data FAIR and make them visible through a joint research data catalogue. ACTRIS has very strong links with international global platforms as well as with ESFRI projects such as ICOS & IAGOS. Current collaboration and synergies identification with all the ENVRI Research Infrastructures, could lead to future operational integration of ACTRIS and ICOS, both from an economic perspective, e.g. sharing of some physical sites, in particular for national stations/nodes/facilities being part/co-located with other RIs, and of support staff; as well as from a scientific perspective, though, for example, overlapping research communities and complementary data collections. An **international** outreach strategy is in place, but it does not specifically focus on international communities nor on the specificities of these communities. Therefore, the next expected step is to perform an international landscape analysis, identifying the international users demands and identifying potential key international partners.

Major Bottlenecks and Possible Measures Which Might impact Further Development
A major bottleneck is that ACTRIS does not have enough resources to develop innovation activities as hoped. Initial costs to set up this type of activity are not seen as necessary by the MS/AC and therefore it is not supported as a core activity of the RI. Although the design of the governance structure and the cost book are in place, there is no information regarding the financial commitment of the MS/AC to ensure the lifelong sustainability of ACTRIS legal model (ERIC).
Recommendations
• Seek project-based resources to initiate innovation activities and recruit the necessary expertise. These activities will have a huge impact on the long-term financial sustainability of ACTRIS. • Widen the user community also exploiting the huge innovation potential of technology development via co-design and co-creation projects with industry, so as to provide market-driven services to the private sector. • Establish collaboration with other e-infrastructures and the development of a virtual research environment, particularly the with EOSC and EuroHPC. • Work on the ESFRI recommendation to start the process of integration of ACTRIS and ICOS in the long term of 5-10 years.

AnaEE

ENVIRONMENT	
	AnaEE **Infrastructure for Analysis and Experimentation on Ecosystems**
The infrastructure for Analysis and Experimentation on Ecosystems (AnaEE) is a distributed Research Infrastructure designed to provide the knowledge needed to support a sustainable future. This infrastructure aims, through state-of-the-art experimental facilities, to support scientists in testing the potential impacts of climate change and land use in Europe, and forecasting the risks on European ecosystems, including agricultural systems. AnaEE will thus enable policymakers, scientists and the industry to develop climate mitigation strategies and provide solutions to the challenges of food security, with the aim of stimulating the growth of a vibrant bioeconomy.	

Typology RI	Distributed
Lead Country	FR
Members	
***Observer (ERIC)**	
Prospective Members	BE, CZ, DK, FR, IL, IT, (LTU)
ESFRI Roadmap Entry	2010
ESFRI Landmark	

<table>
<tr><td rowspan="4">Preparation</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>ANAEE Design</td><td>2008-2010</td><td>0.9</td><td>1.2</td><td></td></tr>
<tr><td>ANAEE</td><td>2012-2016</td><td>3.4</td><td>4.8</td><td></td></tr>
<tr><td>TOT</td><td>2008-2016</td><td>4.3</td><td>6.0</td><td>4.7</td></tr>
<tr><td rowspan="3">Implementation/ Construction</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TOT</td><td></td><td></td><td></td><td>1.1</td></tr>
<tr><td rowspan="5">Collaborative Grants

Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td colspan="2">EUR M (Total)</td></tr>
<tr><td>ENVRI</td><td>2011-2014</td><td>3.7</td><td colspan="2">5.1</td></tr>
<tr><td>ENVRI PLUS</td><td>2015-2019</td><td>14.7</td><td colspan="2">15.0</td></tr>
<tr><td>ENVRI-FAIR</td><td>2019-2022</td><td>19.0</td><td colspan="2">19.0</td></tr>
<tr><td>TOT</td><td>2011-2022</td><td>37.4</td><td colspan="2">39.1</td></tr>
<tr><td>Legal Status</td><td colspan="5">Pending</td></tr>
<tr><td>In Operation since</td><td colspan="5">Foreseen 2019 (Currently in Implementation Phase, ESFRI Project)</td></tr>
</table>

Implementation Readiness Level and Future Outlook

AnaEE entered the ESFRI roadmap in 2010. It is currently in the Implementation Phase and applied for ERIC legal status, Step 1, in 2018. Accordingly, the HLEG assesses AnaEE as being at **RL3**. The infrastructure will move to RL4 once ERIC status is approved as legal setup.

Long-term Sustainability

AnaEE is a pan-European Research Infrastructure consisting of a central coordination body (a Central Hub and three Service Centres) with experimental modelling and analytical facilities (i.e. national platforms) distributed across its Member States. Each Member State is independently responsible of funding the upgrades maintenance and operation of its national platforms. The roles of **governing committees** (Stakeholder Committee, Scientific Committee, and a separate Ethics Committee) should be specified and the committees established. The effective **coordination structure** is very important in view of the high number of platforms, but it is not described in sufficient detail. A coordinated single point access to experimental facilities, data and modelling as well as assistance with experimental design would be assets, if AnaEE is to be seen as the quality standard in the field. However, at the moment it is stated that user projects will be evaluated by the individual platform owner. This reduces the value of the role of AnaEE as a single point access facility.

The Data and Modelling Centre will play a central role in managing the access to data and will maintain metadata catalogues and oversee the development of Data Management Plans and associated **data access processes**. The development and use of suitable metadata standards and simulation datasets that are derived from them will make an important contribution to making these assets discoverable by users or by software systems. The users will come from different science, policy, business and welfare backgrounds and need to ground their decisions on data offering complex interpretations, often difficult to assemble and not directly comparable. AnaEE should elaborate how it will upscale its activities to fulfil the potential needs and what added value it will bring to the users which is not available now. AnaEE does not yet have a budget for the usage of the infrastructure platforms, usage costs will be charged to the users. **Open Access to data** and results are not addressed by AnaEE. Accepting open access should be a condition for being allowed to use AnaEE. AnaEE has high ambitions concerning education and training, AnaEE will train the next generation of scientists and decision-makers to maximise the potential of the collected data. Especially playing a role in the primary and secondary education systems requires lots of resources and expertise. The national platforms could possible play a role in outreach to schools including outreach towards teachers. The **business model** description is not fully elaborated. AnaEE will support industries as innovation developers or as customers, thereby increasing the technological and organisational readiness to develop new ecosystem experiments. It would be useful to develop a common policy and ultimately aim for joint procurement for the national platforms, in order to increase the added value of the role of AnaEE.

From the available documents and the AnaEE website it is difficult to judge whether the RI could achieve its ambitions. The infrastructure project suffered already from some delays (ERIC step 1 application was planned for 2017, the signature of ERIC legal structure was planned for early 2019), and there is no evidence that particular measures were taken to improve the situation. An overall description of how this infrastructure would provide a tool for bringing together the distributed facilities into efficient coordinated operations in order to find solutions for the sustainable use of European wide ecosystems is missing. Many kinds of benefits are listed, but how they link together remains unclear. The consequence of these weaknesses is that it is not made convincingly clear that AnaEE is a true Research Infrastructure and not a more loosely linked network structure.
Major Bottlenecks and Possible Measures Which Might impact Further Development The pan-European relevance is currently a critical point; AnaEE needs to find more partner countries with the perspective of signing the ERIC. The commitment of the participating countries for the Operation Phase and the role and funding of the Central Hub in a legally binding document should be secured. The main challenge for the long-term sustainability of AnaEE is the lack of firm financial commitments from the partners and a low number of countries involved.

Recommendations

- Demonstrate the European added value of AnaEE as a Research Infrastructure rather than a network of national platforms, in particular consolidate the origin and size of the user community, set up a robust business model including staff exchange plan within thematically linked infrastructures and networks, and develop a model for sustainable transnational access. Define a complete access policy and pricing policy for all users approved by all partners.

- Continue to fully exploit synergies with other thematically linked Research Infrastructures, the opportunities for close collaboration or integration with them should be periodically updated contributing to the evolution and optimization of the RI landscape.

- Synergies in the development of data services with complementary RIs should be a priority in the data management policy.

- Develop a sustainable funding model for successful implementation, show the pan-European RI advantages and the benefits to the national communities in order to encourage the member states funding engagements.

- Develop the innovation potential of AnaEE, detail the interest of the relevant industry sectors, foster industry collaborations particularly in the food and health domain.

- If substantial advancement towards fulfilling the scope of a European Research Infrastructure is not achieved, reorient efforts towards establishing a pan-European network of facilities with specific research programmes.

BBMRI ERIC

HEALTH & FOOD

BBMRI ERIC

Biobanking and BioMolecular Resources Research Infrastructure

BBMRI is one of the largest Research Infrastructures for health research in Europe providing a gateway for access to biobanks and biomolecular resources and the associated data coordinated by the National Nodes. It aims at improving the accessibility and interoperability of the existing comprehensive collections, either population-based or clinical-oriented, of biological samples from different (sub-) populations of Europe or rare diseases. These collections include the associated data on factors such as health status, nutrition, lifestyle, and environmental exposure of the study subjects. Its services include guidance on ethical and legal issues on sensitive data management, data standardization and quality management for health research.

Typology RI	Distributed
Lead Country	AT
Members	AT, BE, BG, CZ, DE, EE, EL, FI, FR, IT, LV, MT, NL, NO, PL, SE, UK
***Observer (ERIC)**	CH, CY, TR, (IARC)
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	PROJECT NAME	YEAR-YEAR	EUR M (EU)	EUR M (Total)	EUR M (ROADMAP 2018)
	BBMRI	2008-2011	5.0	7.2	
	TOT	2008-2011	5.0	7.2	NA
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ADOPT BBMRI-ERIC	2015-2019	5.0	5.0	
	TOT	2015-2019	5.0	5.0	NA

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	BIOMEDBRIDGES	2012-2015	10.5	13.7
	BBMRI-LPC	2014-2017	8.0	10.3
	EGI-Engage	2015-2017	8.0	8.65
	B3Africa	2015-2018	2.0	2.0
	CORBEL	2015-2020	14.8	14.8
	RITRAIN	2015-2020	2.0	2.0
	PhenoMeNal	2015-2018	7.7	8.0
	EOSCpilot	2017-2019	10.0	10.0
	EOSC-hub	2018-2020	30	33.3
	AARC2	2017-2019	3.0	3.0
	EDIReX	2018-2022	5.1	5.1
	ID-EPTRI	2018-2020	3.0	3.1
	RI-VIS	2019-2021	1.5	1.5
	ERIC Forum	2019-2022	1.5	1.5
	EOSC-Life	2019-2023	23.7	23.7
	TOT	2012-2022	130.8	140.65
Legal Status	ERIC, 2013			

In Operation since	2014

Implementation Readiness Level and Future Outlook
BBMRI entered the ESFRI roadmap in 2006 and became an ERIC in 2013. It currently includes 20 countries and one international organisation, making it one of the largest European Research Infrastructures. BBMRI-ERIC is assessed at **RL5**. It has finished the Implementation Phase and is expected to move towards RL6 through effective ongoing clustering activities.

Long-term Sustainability

It is acknowledged that BBMRI has done a good job on making the **science case**, i.e. the services were designed based on user inputs, a Scientific Review Board is in place and the RI has a track record of published international peer-reviewed articles. A **user access policy** and a common access portal are in place, including access procedures and services for researchers. These are being developed and implemented in parallel with common services for ethical, legal and societal issues (ELSI) related to access and quality management services for basic and applied research. The profiles and roles and a list of key staff are visible. It provides **staff development and training** mostly via the EMMRI master. Training for the end-users is performed by key BBMRI staff members and disseminated leveraging BBMRI's participation in EU funded projects. Transnational access schemes are implemented through human capital and clusters projects and not directly under BBMRI governance. BBMRI's **innovation** ecosystem is improved by a trustworthy relationship with industry partners: the BBMRI Stakeholder Forum industry pillar provides direct connections with industry key players and disseminates information on the list of services potentially interesting for industry, as well as a serving as a technology transfer brokerage function. This new strategy was set up in 2018 and will be fully implemented in 2020/2021. BBMRI supports the private industry sector needs to access biospecimen and data to develop innovative products to maintain or reach market leadership. Whilst the effort in creating key performance indicators is recognised, those currently proposed are not adequate for BBMRI and should be revised, including social impact assessment. A study on the contribution of BBMRI to the national/ regional smart specialisation strategy is also needed. The common European **data** protection framework and Member States' privacy regulations present considerable difficulties in achieving the exploitation of samples and data in clinical and research environments. BBMRI is working, in partnership with other RIs, to address, standardise and harmonise practices for biobanks, while dealing with broader ethical issues and the connected legal and societal aspects. Although a list of potential **international** partners is identified through two H2020 Health projects, no information on access and IPR with third countries is publicly available which could hamper the international outreach of BBMRI.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Although the funding from the MS/AC for the ERIC operation was committed, BBMRI still captures a significant amount of EU funding through competitive grants where it either provides services to the consortium or collaborates to harmonisation and standardization efforts. The collaboration with other research infrastructures, particularly the alliance with EATRIS and ECRIN, should address a common model for the infrastructure services, maximizing synergies and avoiding redundancies.[A bottleneck is not taking full advantage of the potential innovation impact. The existing industry engagement strategy should be further developed and expanded, to ensure BBMRI supports the development of existing and new biomarkers and commercial kits systems/ diagnostic tests.

Recommendations

- Perform mapping of the regional and thematic innovation ecosystem and develop strategic roadmaps in the area together with other relevant initiatives.
- Continue the expansion of ethical, legal and social issues services to support other RIs that have similar problems avoiding duplication of efforts between RIs.
- Refine a strategy for higher integration of the national investments in biobanks and the pan-European infrastructure.

CERIC ERIC

PHYSICAL SCIENCES & ENGINEERING	
CERIC	**CERIC ERIC** **Central European Research Infrastructure Consortium**

CERIC is an integrated multidisciplinary Research Infrastructure for basic and applied research that provides open access for international users to national research facilities in eight European countries to support science and industry advance in all fields of materials, biomaterials and nanotechnology. It enables the delivery of solutions in the fields of energy, health, food, cultural heritage and more.

Typology RI	Distributed				
Lead Country	IT				
Members	AT, CZ, HR, HU, IT, PL, RO, SI				
***Observer (ERIC)**	RS				
Prospective Members					
ESFRI Roadmap Entry	not on the ESFRI Roadmap				
ESFRI Landmark	not on the ESFRI Roadmap				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ACCELERATE	2017-2021	3.3	3.3	
	TOT	2017-2021	3.3	3.3	
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	E-RIHS	2017 - 2020	3.5	3.5	
	PaNOSC	2018-2022	12.0	12.0	
	ERIC Forum	2019-2022	1.5	1.5	
	TOT	2017-2022	17.0	17.0	
Legal Status	ERIC, since 2014				
In Operation since	2015				

Implementation Readiness Level and Future Outlook

A distributed (multi-sited) Research Infrastructure, CERIC was established by the European Commission implementing decision in mid-2014 and by participating Countries supporting integrating facilities with total existing investments of around EUR 100M, operation costs around EUR 10M, and host Country supporting central activities and integration with EUR 5.5 M/year. It aims "to contribute to European top-level research and technological development, demonstration programs and projects, by integrating into a unique RI the complementary facilities operating in the synthesis and analysis of materials and biomaterials". CERIC brings particular benefits in strengthening the scientific potential of Central European Countries thus significantly contributing to building the European Research Area. CERIC is assessed at **RL5** and has good prospects of progressing towards RL6 when participating Countries beyond Italy become more active funders of the common integrated activities, beyond the purely in-kind model, and when compliance with FAIR principles for data and services (as defined by the EOSC) are achieved.

Long-term Sustainability

CERIC has a clear strategic objective to contribute to the production of **excellent science**, both by serving international users accessing CERIC's infrastructure in eight European Countries as well as through in-house research activity. To access the CERIC infrastructure, potential users can look through the list of available instruments, techniques and access modes at various facilities and laboratories and apply through a single access point, through an international peer-review process. To attract new users, CERIC is finalising its science strategy, has organised outreach events using the support of the ACCELERATE project and offers partial support for users' access and researchers mobility. CERIC supports several internal 3-year-long research projects (five in 2018) which are implemented with the support of joint co-funding as well as a top-up from **Italy as a host country**. To report on science-related and other indicators, the Monitoring Framework (adopted in 2016 and used as a management tool) includes 12 KPIs. **Training** is one of them. The number of students and researchers trained every year has increased over the years from 30 (in 2014) to 282 (in 2018). A particular focus is placed on young researchers through participation in the HERCULES school. Both internal and external career opportunities are internationally advertised, and CERIC personnel took part in mutual training practices carried out with managers and administrative personnel in different RIs. CERIC also organises trainings to get industrial users acquainted with the techniques available for research and development and their industrial applications. Through training of industrial users CERIC aims to exchange and share the know-how and expertise to foster **innovative** solutions to specific industrial needs. CERIC has two dedicated people in the Industrial Liaison team, which provides support to spin-off and start-up companies by putting them in touch with innovation networks, incubators and accelerators. CERIC's statutes mandate it to perform periodic **impact assessments**, which are partly pursued under the ACCELERATE project. An interesting impact angle comes from CERIC's activities in training pupils by setting up a network between schools and RIs to promote scientific careers among high-school pupils. **Exploitation of the data generated** by CERIC and preparation for EOSC integration is pursued under the ACCELERATE (e.g. open data and access policies are addressed in a dedicated package) and PaNOSC (e.g. making scientific data FAIR) projects. A work package in the ACCELERATE project focuses on the enlargement and **International** cooperation and developing policies to support and build world-wide linkages and impact. **Funding** of CERIC has been possible through the active support from Italy, the sole main funder of the integrating activities of CERIC, whereas each participating Country is in charge of funding its own infrastructure and contributes in-kind. On a project basis, funding also comes from the ESIF, thus diversifying the funding streams, in particular in relation to the capital investments. Nevertheless, the funding of the integrating activities so far relies solely on the institutional funding by the Italian Ministry of Education, University and Research (MIUR) and on EU funded competitive projects.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The progress of CERIC as a young RI is tremendous and has been done at a highly professional level in all aspects related to long-term sustainability. However, two bottlenecks need to be addressed to ensure continued success. CERIC is currently focusing its science strategy on two domains: energy and life sciences and needs to strengthen and broaden its user community. Funding, although coming from a combination of national, Framework Programme, and European Structural and Investment Funds, is still a rather limiting factor with over reliance on funding from Italy with other member Countries providing only support to their facilities as in-kind contribution, which is perceived as a bottleneck for further development and long term sustainability.

Recommendations

- Prepare a plan for further targeted efforts to increase the numbers of users and grow user communities within the selected scientific domains.
- Continue negotiations with current members on how to integrate their in-kind contribution with a share of the cash needs.
- As part of the Promotion Strategy and to address the above recommendations, prepare a clear value added and a "business" case of CERIC-ERIC. Existing support to in-house research is undoubtedly one such strong selling point and should continue.

CESSDA ERIC

SOCIAL & CULTURAL INNOVATION

CESSDA ERIC

Consortium of European Social Science Data Archives

CESSDA is a distributed ESFRI Landmark which provides large-scale, integrated and sustainable data services to the social sciences. It brings together social science data archives across Europe, with the aim of promoting the results of social science research and supporting national and international research and cooperation.

Typology RI	Distributed				
Lead Country	NO				
Members	AT, BE, CZ, DE, DK, EL, FI, FR, HU, NL, NO, PT, SE, SI, SK, UK				
***Observer (ERIC)**	CH				
Prospective Members					
ESFRI Roadmap Entry	2006				
ESFRI Landmark	2016				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	CESSDA-PPP	2008-2010	2.7	4.2	
	TOT	2008-2010	2.7	4.2	2.7

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	CESSDA SaW	2015-2017	2.5	2.6	
	TOT	2015-2017	2.5	2.6	78
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	DASISH	2012-2014	6.0	8.3	
	SERISS	2015-2019	8.5	8.9	
	RITRAIN	2015-2020	2.0	2.0	
	RISCAPE	2017-2019	2.0	2.0	
	ERIC FORUM	2019-2022	1.5	1.5	
	SSHOC	2019-2022	14.5	14.5	
	TOT	2012-2022	34.5	37.2	
Legal Status	Limited company under Norwegian law since 2013; ERIC, since 2017				
In Operation since	2013				

Implementation Readiness Level and Future Outlook

An ESFRI Landmark CESSDA is building on the legacy of national archives since 1976. It has been on the Roadmap since 2006 with a growing membership. As a consortium with national members it started in 2013 as a Norwegian not-for-profit company and was transformed into an ERIC in 2017. CESSDA takes an active role and puts substantial efforts into the work around the data and all data related activities linked to the developments of the European Open Science Cloud. CESSDA is assessed at **RL5** and has good prospects of progressing towards RL6 when compliance with FAIR principles for data and services (as will be defined by the EOSC) is achieved.

Long-term Sustainability

Although not generating **scientific** research themselves, CESSDA is the enabler for the social sciences research community to conduct high-quality research. The CESSDA-SaW project focused on "establishing a seamless social science data archive service" thus ensuring benefits to research and the SERISS project influenced social sciences research design and implementation. Through a dedicated Working Group, efforts are put towards **training** of the staff of CESSDA's Service Providers, partner organisations, other data professionals, and researchers in the social sciences and humanities. CESSDA also carries out train-the-trainer activity and offers a collection of resources and events for learning about the management, preservation and distribution of research data. "Renown for TRAINING" is the 2nd pillar in the CESSDA Strategy 2018-2022. Activities unlocking the **innovation** potential and assessing **socio-economic impact** are not clearly noticeable. With regard to knowledge and technology transfer activities CESSDA is a member of the DDI Alliance and has set up metadata profiles, controlled vocabularies management, multilingual thesauri. Engagement with industry (incl. SMEs) is limited to pilots on using semantics to make data interoperable, and provision of access to industry and public sector is absent. The SERISS project tackled socio-economic challenges and has the potential to generate interesting stories about emerging and realised impact. CESSDA's strength lies in the exploration of the **data** generated and archived by the service providers in its membership. The CESSDA Data Catalogue contains metadata of all data from the CESSDA's services providers and currently holds 30,565 entries, of which 21,868 are in English and 8,697 in five other languages. CESSDA is leading the SSHOC project (Social Sciences and Humanities Open Cloud) which aims to prepare for EOSC integration. Substantial efforts are being put into helping their community to make data FAIR, e.g. CESSDA has recently published a self-assessment against the 27 actions in Turning FAIR into Reality report. Activities and accumulated knowledge in data is reflected in solid **international** outreach. CESSDA is part of the Research Data Alliance which provides opportunities to connect with similar organisations in Asia, Australia and Africa and is co-chairing an Interest Group on Social Science Research Data, building strongly on results of the RISCAPE project. CESSDA also plans to build on existing contacts with ICPSR-USA, Dataverse and ARDC-AUS to explore global cooperation, especially on metadata standards, data catalogues and training. CESSDA has set up an international network of potential CESSDA partners and Service Providers. CESSDA's **governance** is in place and the membership has grown to twenty current members and an additional 2-3 in the pipeline.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Despite a wide and increasing membership, the financial sustainability of the Consortium is not really in place. The level of membership income is lower than it was back in 2016; whereas the operating expenses continue to grow. Nearly 80% of overall income comes from only two countries: Norway and Germany. There is a risk associated with over-reliance on this type of funding that might push CESSDA to run for more EC-based grants and shift towards a project-based type organisation creating the risk of overlooking core operations needed to run a distributed RI.

Recommendations

- Re-think membership model (currently GDP-based); develop additional services which can be offered both for members and partners, including from the private sector; investigate a possibility to offer "consulting" services to similar organisations or Service Providers outside the EU. All these should be developed into a solid business plan, discussed with the CESSDA's Governance and based for future membership.

- Showcase stories and examples about how CESSDA actually led to scientific excellence in the work of selected researchers. Such success stories will serve as a strong base for demonstrating the added value of this RI, potentially helpful in negotiating national contributions.

- Track performance (incl. scientific excellence) through a number of KPIs agreed with the CESSDA Governance, especially the representatives of the funding institutions in CESSDA's member countries. These KPIs should be part of CESSDA's annual reporting.

- Make CESSDA's data access and management policies visible at the level of the Data Catalogue. 2

- Perform a socio-economic impact assessment of CESSDA's activities, which would also cover innovation potential and outputs. The results can be used in 'fund-raising' activities nationally. In developing criteria for socio-economic impact assessment, include contribution of CESSDA to regional smart specialisation strategies.

CLARIN ERIC

SOCIAL & CULTURAL INNOVATION	
CLARIN Common Language Resources and Technology Infrastructure	**CLARIN ERIC** **Common Language Resources and Technology Infrastructure**

CLARIN is a distributed RI that provides easy and sustainable access for scholars in the humanities and social sciences to digital language data – in written, spoken or multimodal form – and advanced tools to discover, explore, exploit, annotate, analyse or combine them, independent of their location. To this end, CLARIN is building a networked federation of language data repositories, service centres and centres of expertise, with single sign-on access for all members of the academic community in all participating countries.

Typology RI	Distributed
Lead Country	NL
Members	AT, BG, CY, CZ, DE, DK, EE, EL, FI, HR, HU, IT, LT, LV, NL, NO, PL, PT, SE, SI, (DLU)
***Observer (ERIC)**	FR, UK
Prospective Members	IS, ZA
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

<table>
<tr><td rowspan="3">Preparation</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>CLARIN</td><td>2008-2011</td><td>4.1</td><td>5.6</td><td></td></tr>
<tr><td>TOT</td><td>2008-2011</td><td>4.1</td><td>5.6</td><td>4</td></tr>
<tr><td rowspan="3">Implementation/ Construction</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>CLARIN-PLUS</td><td>2015-2017</td><td>1.5</td><td>1.5</td><td></td></tr>
<tr><td>TOT</td><td>2015-2017</td><td>1.5</td><td>1.5</td><td>NA</td></tr>
<tr><td rowspan="7">Collaborative Grants

Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td colspan="2">EUR M (Total)</td></tr>
<tr><td>DASISH</td><td>2012-2014</td><td>6.0</td><td colspan="2">8.3</td></tr>
<tr><td>PARTHENOS</td><td>2015-2019</td><td>12.0</td><td colspan="2">12.0</td></tr>
<tr><td>EOSC-hub</td><td>2018-2020</td><td>30.0</td><td colspan="2">33.3</td></tr>
<tr><td>ERIC FORUM</td><td>2019-2022</td><td>1.5</td><td colspan="2">1.5</td></tr>
<tr><td>SSHOC</td><td>2019-2022</td><td>14.5</td><td colspan="2">14.5</td></tr>
<tr><td>TOT</td><td>2012-2022</td><td>64.0</td><td colspan="2">69.6</td></tr>
<tr><td>Legal Status</td><td colspan="5">ERIC, since 2012</td></tr>
<tr><td>In Operation since</td><td colspan="5">2012</td></tr>
</table>

Implementation Readiness Level and Future Outlook

The number of CLARIN ERIC members has increased from nine in 2012 to twenty members and four observers. CLARIN entered the ESFRI roadmap in 2006 and is now an ESFRI Landmark. CLARIN has been fully operational since 2015 and is assessed by the HLEG as being at RL5. CLARIN is currently working to develop advanced FAIR data services through participation in SSHOC. CLARIN has strong potential to progress towards RL6.

Long-term Sustainability

CLARIN have been developing KPIs for continuous evaluation of their outputs, tracking usage and monitoring **scientific excellence**. This will require the development of a strategy to stimulate users to acknowledge the RI in order to increase the visibility of CLARIN. This activity can be done with the support of the Scientific Advisory Board that is already in place. The administrative capacity of the CLARIN Central Office has been professionalised and staff in charge of external relations have been appointed. This has been beneficial for the exchange of information with stakeholders and the overall visibility of CLARIN in the political landscape. Although **training** opportunities for researchers are in place, there is no specific training for staff (in order to train them in areas such as management of RIs, HR management, amongst others). There is a potentially very large user base in SSH (estimated at 500,000 researchers across Europe) but there is limited awareness of RIs such as CLARIN. Under-exploitation of the RI may be attributed to a general lack of academic prestige of work conducted in the context of RIs, but also to little knowledge of career paths beyond "traditional" academia, limited technical and/or methodological knowledge in "traditional" disciplines, and scarce visibility of RIs in formal and informal education. The ERIC assessment found that the data and tools generated and/or disclosed by the RI could be better exploited if they were better aligned with the leading research agendas in SSH, if overlap in decentralised development were better monitored. A clear **innovation** strategy needs to be developed and put in place to reach industry and other areas beyond SSH. Regarding **socio-economic impact,** CLARIN needs to develop and monitor a set of indicators to measure their environmental, social, cultural, economic and political impact. CLARIN has championed the Open Science and FAIR agendas and has a well-defined access policy and policies for data protection, as well as a template for Terms of Service. Although the **data management plan** policies are in place, they are inconsistent within and between member countries Collaboration between CLARIN and DARIAH, in the SSH domain, has been supported through the PARTHENOS cluster project where a model was developed which focuses on identifying areas where there is an overlap in user needs and to assess the potential for developing common solutions. In the context of the H2020 cluster project SSHOC, which also includes the ERICs from the social sciences as lead beneficiaries, this form of collaboration should be continued and extended. CLARIN also participates in ERIC Forum. An active outreach policy aimed at widening the user base and setting up formal alliances with parties outside of Europe is in place, however, no information regarding the programme is publicly available.

Major Bottlenecks and Possible Measures Which Might impact Further Development
CLARIN ERIC has a financial reserve that will enable the Research Infrastructure to cope with income reductions. However, training agendas for formal and informal education and alignment with the SSH research agenda should be developed to increase the academic impact of CLARIN.
Recommendations
• Although collaboration with other RIs have intensified, the data and tools generated and/or disclosed by the CLARIN ERIC could be better exploited if they were better aligned with the leading research agendas in SSH. • Given potential areas of overlap, CLARIN should periodically review its place in the SCI-SSH domain and consider the potential for reorientation of the RI and/or possible closer integration with other RIs in SCI-SSH (e.g. DARIAH) over the longer-term. • Explore possible models to offer knowledge and services for the data science sector and the cultural industry. This way CLARIN can act as an innovation hub while at the same time strengthening its own socio-economic and financial position. • Develop and keep up to date a list of social-economic indicators.

DANUBIUS-RI

<table>
<tr><th colspan="2">ENVIRONMENT</th></tr>
<tr><td></td><td>DANUBIUS-RI

International Centre for Advanced studies on River-Sea Systems</td></tr>
<tr><td colspan="2">DANUBIUS-RI, the International Centre for Advanced Studies on River-Sea Systems, is a distributed environmental Research Infrastructure whose mission is to achieve healthy River-Sea Systems and advance their sustainable use. DANUBIUS-RI offers a new paradigm in aquatic science: the River-Sea continuum approach which aims to overcome the current fragmentation of science, knowledge, data and management in rivers and seas by integrating spatial, temporal, disciplinary and sectorial thinking.</td></tr>
</table>

<table>
<tr><td>Typology RI</td><td colspan="5">Distributed</td></tr>
<tr><td>Lead Country</td><td colspan="5">RO</td></tr>
<tr><td>Members</td><td colspan="5"></td></tr>
<tr><td>*Observer (ERIC)</td><td colspan="5"></td></tr>
<tr><td>Prospective Members</td><td colspan="5">BG, CZ, DE, EL, ES, HU, IE,IT, MD, NL, RO, UK, UA</td></tr>
<tr><td>ESFRI Roadmap Entry</td><td colspan="5">2016</td></tr>
<tr><td>ESFRI Landmark</td><td colspan="5"></td></tr>
<tr><td rowspan="3">Preparation</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>DANUBIUS-PP</td><td>2016-2019</td><td>4.0</td><td>4.3</td><td></td></tr>
<tr><td>TOT</td><td>2016-2019</td><td>4.0</td><td>4.3</td><td>2.0</td></tr>
</table>

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				222
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	ENVRI-FAIR	2019-2022	19.0	19.0	
	TOT	2019-2022	19.0	19.0	
Legal Status	Pending (ERIC statutes are to be submitted in 2020)				
In Operation since	Foreseen 2022 (Currently in Preparation Phase, ESFRI Project)				

Implementation Readiness Level and Future Outlook

Initial planning for the Research Infrastructure started in 2006 and DANUBIUS entered the ESFRI Roadmap in 2016. DANUBIUS completed its Preparatory Phase project on 30 November 2019 which addressed the governance, legal and financial planning for the future DANUBIUS-RI. ERIC status will be applied for in 2020. The HLEG assesses DANUBIUS as being at **RL3**. Progression to RL4 depends upon the success of ongoing efforts to secure financial commitments from current members for the Implementation Phase.

Long-term Sustainability

During the Preparatory Phase, funding commitments have been given by four Countries (Germany, Italy, Romania and Spain) with political commitment from a further seven (Bulgaria, Greece, Hungary, Ireland, Moldova, Netherlands and UK). **International** expressions of interest and support have been received from an additional sixteen European and non-European Countries. Through DANUBIUS-PP, the RI has begun negotiations on developing its funding plan for implementation with all members. However, while discussions have been held with university and other organisations in Austria over co-financing the implementation of an Upper Danube Supersite, DANUBIUS have so far been unsuccessful in engaging with ministerial representatives in this country. However, DANUBIUS state that securing funding for the Implementation Phase will only be possible if Member States and Associated Countries commit to financing the Operation Phase. According to the most recent DANUBIUS PP newsletter (October 2019), draft statutes are being prepared and were to be discussed at a Board of Governmental Representatives (BGR) meeting which took place in November 2019. The DANUBIUS statutes will be submitted to the European Commission in 2020. In relation to the ongoing ERIC statutes and **governance** negotiations, DANUBIUS has developed an approach where member contributions are based on a fixed, maximum number of person-months, assets made available for use by the RI, and data. As such, DANUBIUS-RI hopes to avoid the challenge of estimating in-kind contributions that is common to many RIs. While DANUBIUS aims to provide open access to their **catalogue of services**, market-driven access will be charged at full cost plus a reasonable margin. DANUBIUS is currently registered on the Romanian National Roadmap, has succeeded in securing funding from Germany and Italy, and from the Scottish participating institutions, and is currently preparing more funding applications in Romania, Spain and Greece. However, the rigidity of these funding structures presents challenges (i.e. being dependent upon being on National Roadmaps, ineligibility of salary and service-related costs). At the time of drafting this report, there was a general lack of visibility of the DANUBIUS Preparatory Phase project results via the project or main RI website. Since then, there have been a number of improvements made however more work on better aligning the news section of the PP and main RI website is still needed.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The funding of DANUBIUS for the Implementation Phase depends on Member States and Associated Countries committing to financing the Operation Phase. While there has been success in securing political will for this, there remains, in some cases, a need to translate this into a solid financial commitment. DANUBIUS has defined a pricing policy for their services that includes a range of service levels offered at reduced fees for members and at full cost plus a margin for market-driven access. The policy will be adjusted once the first e-services hit the market in 2023 and demand can be reviewed. An assessment of the effectiveness of this approach will be valuable for supporting longer-term sustainability and there are plans to carry out a pilot based on a transnational access project application in 2020.

Recommendations

- As a matter of urgency, DANUBIUS should work to secure the financial commitments for the implementation stage by all current members.
- Testing of the DANUBIUS funding model should be prioritised in the short-term and there could be benefit in taking advantage of the expertise among the ERIC Forum partners for assessing its effectiveness
- The main DANUBIUS website should be populated with more comprehensive and up to date content to serve as a better marketing tool for the RI.

DARIAH ERIC

SOCIAL & CULTURAL INNOVATION	
	DARIAH ERIC **Digital Research Infrastructure for the Arts and Humanities**
DARIAH, the Digital Research Infrastructure for the Arts and Humanities, is a pan-European infrastructure for arts and humanities scholars working with computational methods. It supports digital research as well as the teaching of digital research methods.	

Typology RI	Distributed				
Lead Country	FR				
Members	AT, BE, BG, CY, CZ, DE, DK, EL, FR, HR, IE, IT, LU, MT, NL, PL, PT, RS, SI				
***Observer (ERIC)**					
Prospective Members					
ESFRI Roadmap Entry	2006				
ESFRI Landmark	2016				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	Preparing DARIAH	2008-2011	2.5	3.7	
	TOT	2008-2011	2.5	3.7	3.7

<table>
<tr><td rowspan="4">Implementation/ Construction</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>HaS DARIAH</td><td>2015-2017</td><td>1.9</td><td>1.9</td><td></td></tr>
<tr><td>DESIR</td><td>2015-2019</td><td>2.7</td><td>2.7</td><td></td></tr>
<tr><td>TOT</td><td>2015-2019</td><td>4.6</td><td>4.6</td><td>3.3</td></tr>
<tr><td rowspan="7">Collaborative Grants

Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td colspan="2">EUR M (Total)</td></tr>
<tr><td>DASISH</td><td>2012-2014</td><td>6.0</td><td colspan="2">8.3</td></tr>
<tr><td>PARTHENOS</td><td>2015-2019</td><td>12.0</td><td colspan="2">12.0</td></tr>
<tr><td>RITRAIN</td><td>2015-2020</td><td>2.0</td><td colspan="2">2.0</td></tr>
<tr><td>ERIC FORUM</td><td>2019-2022</td><td>1.5</td><td colspan="2">1.5</td></tr>
<tr><td>SSHOC</td><td>2019-2022</td><td>14.5</td><td colspan="2">14.5</td></tr>
<tr><td>TOT</td><td>2012-2022</td><td>36.0</td><td colspan="2">38.3</td></tr>
<tr><td>Legal Status</td><td colspan="5">ERIC, since 2014</td></tr>
<tr><td>In Operation since</td><td colspan="5">Since 2019 (Currently in Operation Phase, ESFRI Landmark)</td></tr>
</table>

Implementation Readiness Level and Future Outlook

DARIAH entered the ESFRI Roadmap in 2006 and became a Landmark in 2016. It has been an ERIC since 2014. DARIAH represents an advanced community which has been active for more than a decade. Operational since August 2019, DARIAH offers open access to its resources and is an active advocate for Open Science and FAIR data. DARIAH leads work in relation to education and training for researchers and actively collaborates with other RIs to tackle common challenges. DARIAH has a strong international dimension and is assessed as being at **RL5**. DARIAH has a long track record of collaboration with other RIs - in most cases through EC support - and currently participates in the SSHOC cluster project. To support longer-term sustainability and full progression to RL6, DARIAH should continue to seek additional members and, where feasible, to diversify its funding streams to minimise risk. However, it is recognised that the effort needed to secure new funding streams can be significant and, accordingly, will require careful planning to ensure that such efforts do not detract from DARIAH's ability to deliver its core mission to national members.

Long-term Sustainability

DARIAH has made significant progress towards strategic and operational consolidation to maximise its **scientific impact** and operational efficiency since the 2013 Assessment Expert Group (AEG) review. Much of this work has been supported through EC projects (Humanities at Scale, DESIR). A key development has been the recent approval of the first 6-year Strategic Plan which will become the foundation for decision-making related to resource allocation, staffing and recruitment, and performance assessment. DARIAH has defined **KPIs** and the 2019 performance data will be gathered between January-May 2020 and released as a part of the 2019 Annual Report. With regards to **attracting and training the managers, operators and users of tomorrow**, DARIAH benefitted – both as project partners and student sponsors – from participation in the RItrain project which provided them with access to formal expertise in RI management. Via the Humanities at Scale project, DARIAH has developed a tool to measure **in-kind support** to improve the reporting and assessment of national contributions to the RI. Despite an initial Innovation Forum being run in 2017 to engage with industry and foster **innovation**, DARIAH does not seem to have run any subsequent events and state that the potential for industrial applicability of humanities and arts research remains largely untapped. In 2018 – in cooperation with other RIs and initiatives – DARIAH developed a Heritage Data Reuse Charter which supports the FAIR principles and is intended to be a moral contract that all researchers and cultural heritage institutions should adhere to. DARIAH note that providing openly accessible services makes tracking their use and measuring **impact** difficult. The 2017 and 2018 annual reports describe the introduction of a User Barometer to provide a snapshot of DARIAH's user community. The User Barometer will be put into full use as part of the KPI implementation due to take place in 2020. DARIAH actively engages in **internationalisation** activities and had a particular emphasis on building ties with Australia in 2019. DARIAH also has a long history of **collaboration** with related RIs in the SSH domain. In particular, there has been close cooperation with CLARIN over the years and more recently with E-RIHS and OPERAS Preparatory Phase projects in which DARIAH is also a partner. There is a **catalogue of tools** available via the website, however access to each tool could be simplified to appear better integrated.

Major Bottlenecks and Possible Measures Which Might impact Further Development
From the ERIC statutes, it is evident that Germany is the largest cash contributor (comprising 36% of the total). At the time that DARIAH's statues were approved, Germany's commitment could only be given to February 2016 and their ongoing participation is linked with national project grant cycles. While Germany's commitment has remained strong in the years since 2016, there remains a risk - however small - that should Germany drop out, DARIAH would face significant financial hardship that would impact its ability to deliver the core mission of the RI. The 2018 annual report shows that staff costs make up 70% of DARIAH's total operational costs which reflects the nature of DARIAH's activities. While these staff costs are justified, DARIAH's longer-term sustainability may be strengthened by seeking to reduce the imbalance that currently exists between cash and in-kind income streams.
Recommendations
• Explore options for realising a better balance between cash and in-kind contributions for ensuring DARIAH's long-term sustainability. • Fully exploit synergies with other Research Infrastructures in the SSH domain (for example CLARIN) and periodically assess the opportunities for closer collaboration and/or integration between them. • Assess the potential value in resuming the Innovation Forum activity. • Based on outcomes of applying the User Barometer during DARIAH's KPI implementation, assess the potential value of the tool for use by other RI.

E-RIHS

SOCIAL & CULTURAL INNOVATION	
E-RIHS EUROPEAN RESEARCH INFRASTRUCTURE FOR HERITAGE SCIENCE	**E-RIHS** **European Infrastructure for Heritage Science**
E-RIHS is an infrastructure for cultural and natural heritage interpretation, preservation, documentation and management. E-RIHS provides state-of-the-art tools and services to the multidisciplinary communities of researchers working to advance the knowledge of world heritage and of its preservation strategies.	

Typology RI	Distributed				
Lead Country	IT				
Members					
***Observer (ERIC)**					
Prospective Members	BE, CY, CZ, DE, EL, ES, FR, HU, IE, IL, IT, NL, PL, PT, SI, UK				
ESFRI Roadmap Entry	2016				
ESFRI Landmark					
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	E-RIHS PP	2017-2020	4.0	4.0	
	TOT	2017-2020	4.0	4.0	4.0

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				20.0
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ARIADNE	2013-2017	6.5	8.4	
	CHARISMA	2015-2017	5.9	5.9	
	IPERION CH	2015-2019	8.0	8.2	
	IPERION HS	2020-2023	6.1	6.5	
	TOT	2013-2023	26.5	29.0	
Legal Status	Pending				
In Operation since	2025 (Currently in Preparation Phase, ESFRI Project)				

Implementation Readiness Level and Future Outlook

E-RIHS entered the ESFRI Roadmap in 2016. It represents an advanced community that has emerged through a number of EC projects including EU-ARTECH, CHARISMA, IPERION-CH, and ARIADNE. E-RIHS was given dedicated support for its early phase development under INFRADEV-02-2016 and the E-RIHS Preparatory Phase project runs until September 2020. The RI has already established strong international connections and is working towards becoming a global distributed infrastructure via G-RIHS. E-RIHS is expected to achieve ERIC status in 2022 and begin full operations in 2025. Through IPERION-CH, several national Research Infrastructure initiatives supporting the delivery of E-RIHS's core mission have already started to be implemented. E-RIHS is due to undergo its first ESFRI review in late 2019/early 2020. E-RIHS is assessed as being at **RL3**. Continued efforts to consolidate the field of heritage science and E-RIHS's role in supporting it will be necessary in order to support the progression to RL4.

Long-term Sustainability

E-RIHS's **scientific excellence** has been recognised by both the Heritage Science community and EU Ministers responsible for Cultural and European Affairs. Twelve Countries supported the ESFRI application in 2015, sixteen Countries joined the preparatory project in 2016, and twenty-nine Countries are currently participants or observers. However, with regard to **sustainable long-term funding**, the need for EC contributions will remain critical through the implementation stage and, likely, beyond it. E-RIHS has commissioned a cost-benefit analysis (CBA) and a **socio-economic impact** assessment. The results of the analysis show that a very high number of transnational users (650) is needed to ensure that costs do not exceed benefits. E-RIHS is in the process of developing different usage scenarios and cost models to ensure that benefits can be realised. E-RIHS has a well-established **international** presence that is the basis for foreseeing the G-RIHS. E-RIHS also has close connections with related RIs such as DARIAH and CERIC – both of which are partners in the E-RIHS Preparatory Phase project – and is a collaborating organisation in the SSHOC **cluster**. An initial attempt at defining **KPIs** for communications about the RI were developed as part of the E-RIHS PP project. In light of the cost-benefits analysis, these should be adjusted moving forward to emphasise facilitating sufficient TA users and to ensure their effectiveness for driving the operations and delivery of the RI. E-RIHS aims to be an infrastructure where scientific results are shared assets that may be found, accessed and re-used and E-RIHS's DIGILAB specifically aims to provide FAIR access to heritage **data**. E-RIHS participation in SSHOC will also provide valuable insights on the practical aspects of FAIRifying Social and Cultural Innovation data. E-RIHS states that it will adhere to the Heritage Data Re-Use Charter developed by DARIAH and IPERION CH to promote data reuse amongst its user community. As its own **data policy** is developed, E-RIHS should make it publicly visible via the RI website.

Major Bottlenecks and Possible Measures Which Might impact Further Development

E-RIHS's excellence of the science mission has been recognised. Nevertheless, the growth of the RI must proceed along with the consolidation of the Heritage Science research community whose current fragmentation represents a bottleneck. This issue was picked up in the periodic assessment report for E-RIHS PP which stated that identity could be a problem for E-RIHS - both in terms of what Heritage Science is and E-RIHS's role in supporting it. The results of the cost-benefit analysis revealed that the minimum number of transnational users needed is 650. E-RIHS note that the IPERION-CH project already offers transnational access activities that target cultural heritage organisations and industry as well as academic researchers. As noted above, E-RIHS are currently developing usage scenarios and associated cost models in light of the cost benefit study. As this work continues, E-RIHS should, in parallel, seek to identify alternate means of funding user access in the absence of EC project support.

Recommendations

- The communication and dissemination activities of E-RIHS should be targeted towards solidifying the concept of Heritage Science, also at the global scale, and promoting E-RIHS's role in supporting it.

- E-RIHS should identify alternate funding mechanisms to support user access and to ensure sustainability of the RI.

- Synergies with other Research Infrastructures in the SSH domain should be fully exploited and the opportunities for closer collaboration and/or integration between them should be periodically assessed.

EATRIS ERIC

<table>
<tr><th colspan="2">HEALTH & FOOD</th></tr>
<tr><td></td><td>EATRIS

European Advanced Translational Research Infrastructure in Medicine</td></tr>
<tr><td colspan="2">EATRIS is a European Research Infrastructure for translational medicine involving over ninety leading institutes, across thirteen EU Member States. EATRIS provides access to the entire pipeline of academic translational medicine infrastructure and expertise and optimises the route from discovery to proof-of-concept in medicine development.</td></tr>
</table>

<table>
<tr><td>Typology RI</td><td colspan="5">Distributed</td></tr>
<tr><td>Lead Country</td><td colspan="5">NL</td></tr>
<tr><td>Members</td><td colspan="5">BG, CZ, ES, FI, FR, IT, LU, NL, NO, PT, SE, SI</td></tr>
<tr><td>*Observer (ERIC)</td><td colspan="5">LV</td></tr>
<tr><td>Prospective Members</td><td colspan="5">RO, HU, LV, BE, IE</td></tr>
<tr><td>ESFRI Roadmap Entry</td><td colspan="5">2006</td></tr>
<tr><td>ESFRI Landmark</td><td colspan="5">2016</td></tr>
<tr><td rowspan="3">Preparation</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>EATRIS</td><td>2008-2011</td><td>4.2</td><td>5.5</td><td></td></tr>
<tr><td>TOT</td><td>2008-2011</td><td>4.2</td><td>5.5</td><td>5.0</td></tr>
</table>

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EATRIS-Plus	2020-2023	5.0	5.0	
	TOT	2020-2023	5.0	5.0	4.5
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	EURIPRED	2013-2017	8.5	10.9	
	CORBEL	2015-2020	14.8	14.8	
	RITRAIN	2015-2020	2.0	2.0	
	TRANSVAC-2	2017-2022	10.6	10.6	
	ID-EPTRI	2018-2020	3.0	3.1	
	RI-VIS	2019-2021	1.5	1.5	
	ERIC FORUM	2019-2022	1.5	1.5	
	EOSC-Life	2019-2022	23.7	23.7	
	iNEXT-Discovery	2020-2024	10.0	10.0	
	TRANSVAC-DS	2020-2022	1.9	1.9	
	ENRIITC	2020-2022	1.5	1.5	
	TOT	2012-2024	89.5	95.2	
Legal Status	ERIC, since 2013				

In Operation since	2013

Implementation Readiness Level and Future Outlook
EATRIS is an ESFRI Landmark that has been on the Roadmap since 2006. It achieved ERIC status in 2013. It is in its Operation Phase and its membership is increasing. The provision of FAIR data has been central to its mission since its inception. EATRIS has been active in clustering around common work areas with other Research Infrastructures of the biomedical sector for several years and it is currently participating in EOSC Life and the ERIC Forum. EATRIS is assessed as being at **RL5** and is progressing towards RL6.
Long-term Sustainability
The 2013 Assessment Expert Group (AEG) recommended that an investment strategy be developed to ensure that EATRIS institutes can upgrade their service and quality levels to sustain their **scientific excellence.** EATRIS has established a central Quality Initiative to improve operations performance of analytical systems but states that supporting this work is a challenge because there are very few funding instruments directly targeted to support initiatives tackling reproducibility. EATRIS signed a long-term collaboration agreement with BBMRI and ECRIN in February 2019 with the aim of developing a collaborative Medical RIs framework to accelerate the development of new tools and offer multi-infrastructure services to both academia and industry. The collaboration is intended to lead to better services for the biomedical community and to support more **cost-effective research** and development processes. EATRIS stresses that it can be difficult to quantify impact relating to biomedical research and development where timelines can run into tens of years. Through the RI-PATHS project, EATRIS will develop its own **impact assessment** methodology in 2020. EATRIS actively supports the FAIRification of data but states that unless the design and execution process in the wet lab change towards advanced standardisation, there is a risk of ending up with clouds populated by non-reproducible data-sets. EATRIS and other RIs in the life sciences have a key role to play in defining and supporting good practices at the laboratory level to ensure FAIR data production. The ERIC assessment stated that the **catalogue of services** and platforms provided by EATRIS members should be further clarified. While there is now a clear list of platforms on the EATRIS website, it is still not entirely clear how an end user would go about requesting access. With regard to **innovation**, dedicated effort has been put into engaging with industry resulting in several industrial partnerships (e.g., a recent GSK partnership). The **longer-term sustainability** of the EATRIS financial model will be a key focus of the H2020-INFRADEV-3 EATRIS Plus project which will start in early 2020 and run for four years.

Major Bottlenecks and Possible Measures Which Might impact Further Development
While EATRIS has managed to increase its membership since becoming an ERIC in 2013, longer-term commitment from Member States is still needed. EATRIS operates on a rolling membership basis which means that countries could drop out at short notice which poses a significant funding risk. EATRIS also cites a need for access to small, fast, high volume funding instruments to support international collaborations as tight central budgets needed to cover user access, review, outreach, education, and stakeholder management don't stretch to facilitate participation in international events or initiatives.
Recommendations
• It is recommended that in addition to reviewing the rolling membership approach, EATRIS continue to diversify its income streams by seeking a larger number of industrial end users. To this end, clearer access procedures and fee structures for members, non-members and industry users are needed. • EATRIS should assess the feasibility of introducing value-added services such as training that could be used to augment the limited central budget. This might be undertaken most effectively as part of the planned cooperation to develop a Medical RI framework. • Through their participation in the ERIC Forum, EATRIS could seek to develop a set of shared recommendations targeted to funding bodies around securing endorsement for, and/or mandating of, the use of the RIs in new funding applications. There may be potential to explore the use of a voucher system as a means of facilitating this. • It is recommended that EATRIS seek a leading role in developing lifecycle related training to support the production of FAIR data in the life sciences. This may be done cooperatively with other RIs and initiatives actively working to target and train early career researchers and data stewards such as the CODATA/RDA Data Science School.

ECCSEL ERIC

ENERGY

ECCSEL ERIC

European Carbon Dioxide Capture and Storage Laboratory Infrastructure

European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL) brings together selected Centres of Excellence on Carbon Dioxide Capture, Transport, Utilisation and Storage (CCUS) across Europe with a vision to enable low to zero CO2 emissions from industry and power generation to help combating climate change. Currently it consists of 81 research facilities from 22 universities, research institutes and industry in the five ECCSEL member countries.

Typology RI	Distributed				
Lead Country	NO				
Members	FR, IT, NL, NO, UK				
***Observer (ERIC)**					
Prospective Members	CH, PL, ES, DK, SE, D				
ESFRI Roadmap Entry	2008				
ESFRI Landmark	2018				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ECCSEL	2011-2012	1.5	2.6	
	ECCSEL PP2	2013-2014	1.2	1.9	
	TOT	2011-2014	2.7	4.5	10

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ECCSEL	2015-2017	3.3	3.3	
	ECCSELERATE	2020-2023	3.5	4.9	
	TOT	2015-2023	6.8	8.2	100
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ERIC FORUM	2019-2022	1.5	1.5	
	TOT	2019-2022	1.5	1.5	
Legal Status	ERIC, since 2017				
In Operation since	2016				

Implementation Readiness Level and Future Outlook

ECCSEL is an ESFRI Landmark in Operation Phase legally set up as ERIC. It has been on the Roadmap since 2008. A number of facilities in five participating countries are operational and used for research projects. Further upgrades and construction are currently being completed while others are in the pipeline. ECCSEL acts as a central hub of the distributed RI, coordinating access and operations of several facilities under the joint umbrella “ECCSEL ERIC” but a clear service-driven approach as well as a value proposition of the Central Hub are lacking. ECCSEL is assessed at **RL4** and substantial efforts are needed to progress towards RL5, e.g. assuring a robust scheme of operation.

Long-term Sustainability

Use of linked facilities by means of transnational access should ensure **scientific excellence**. European and international measures and legislation to tax CO2 pollution encourages the community to look for solutions to capture and store instead of releasing the CO2 into the atmosphere. This legislative measure boosts the focus on CCS, which should also lead to increased industry need for the ECCSEL facilities. Access to national facilities benefits from national funding, or at users' cost, but transnational access so far has been to some degree dependent on available EC funding. Gaps in EC funding affected the **attraction and training** of users, managers and operators. Courses and training by ECCSEL Operations Centre were organised under the ECCSEL 2015-2017 project. Participation in numerous summer schools, hosting of summer schools, staff exchange between the participating facilities and internal training are happening within the individual facilities, frequently sponsored by or with involvement of ECCSEL. The governance structure includes an **Industry** Advisory Board and an industry workshop was held in June 2019. More specific efforts must be done to reach the goals of "attracting industrial participants" set by the ECCSEL 2015-2017 project. Actions towards d**ata exploitation, internationalisation and socio-economic impact** of RI are under development: the data policy covers data exploitation, negotiations are ongoing towards establishing a cooperation agreement with Australia and Japan, and involvement in ERIC Forum should develop the understanding about socio-economic impacts. To ensure a longer-term success, effective **governance** and sustainable long-term **funding** is the most crucial topic. The expectations are that the founding members who have committed to fund ECCSEL for five years (thus covering current annual EUR 0.48M operation costs) will carry on, and additional resources will come when new members join. Although the membership has not grown since the start of the ERIC, ECCSEL is negotiating with potential new members outside and within the framework of the new project ECCSELERATE. One of its goals (and allocated funds) is to bring at least one new MS/AC per year. Although the ERIC status should imply effective governance and a basis for sustainable long-term funding, it does not guarantee these without substantial effort and commitment in place. The new project ECCSELERATE is set to cover important topics for long-term sustainability, i.e. expanding membership, developing national nodes, increasing and sharing of facilities by industry, and international cooperation. These topics were also part of previous projects focused on the establishment of a starting ERIC, but ECCSEL should be now in the position of building on those to accomplish the newly set goals of ECCSELERATE.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The main issue with ECCSEL lies in a weak and under-developed vision and “business” case for central operations in delivering a connected pan-European RI rather than simply a network of national facilities. On the one hand, ECCSEL works to coordinate necessary infrastructure investments thereby reducing overcapacity and cost at a European scale. On the other hand, ECCSEL helps building facilities which are not possible (i.e. too expensive) at the level of one research institution or a single Country. Despite the three dedicated projects from the EC, a vision of ECCSEL as a connected pan-European RI has not progressed enough and the lack of a strong value proposition of a distributed RI with commitment to an organic growth model remains the major bottleneck. The value-added of ECCSEL as a distributed RI and the use of RI funding in supporting it critically depends on the results of the new ECCSELERATE grant, especially in securing long-term funding commitment.

Recommendations

- Revisit the vision and model, agree a stable financial commitment from current members and prepare a feasible plan for growing its membership.
- Review cooperation with other Research Infrastructures and come up with a plan for maximising synergies in science and innovation.
- Promote the access to the nodes through a unified catalogue of services coordinated by the Central Hub also offering help desk for users and service providers.
- Prepare a plan for sustainability of access to research facilities in case of discontinuity of EC funds, building on the current self-funded or fee-based-access practices to cover all transnational access services.
- Align data exploitation plan (which is currently being developed) to all FAIR data and services criteria of EOSC.
- Prepare and implement an annual training programme for staff (e.g. exchange programme) and users (e.g. webinars) as an added value of ECCSEL ERIC as a central hub.
- Prepare and implement a multi-year programme including schemes of industrial engagement. It should go beyond the EU borders thus also building ECCSEL's international outreach.

ECRIN ERIC

HEALTH & FOOD	
EUROPEAN CLINICAL RESEARCH INFRASTRUCTURE NETWORK	**ECRIN ERIC** **European Clinical Research Infrastructure**
The European Clinical Research Infrastructure Network (ECRIN) is a distributed RI that supports the conduct of multinational, high-quality, transparent clinical trials by overcoming the obstacles caused by fragmentation and poor interoperability of the national clinical research environment in Europe. ECRIN creates added value through access to expertise and patients, increasing the reach, diversity, and result quality of clinical trials. As such, it fulfils the vision of a society where all decisions in medical practice are based on sound scientific evidence from high-quality clinical research. It coordinates a paediatric module – PedCRIN and a project for personalised medicine PERMIT.	

Typology RI	Distributed
Lead Country	FR
Members	CZ, DE, ES, FR, HU, IE, IT, NO, PT
***Observer (ERIC)**	CH, PL, SK
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ECRIN-PPI	2008-2011	6.8	9.0	
	TOT	2008-2011	6.8	9.0	6
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ECRIN-IA	2012-2018	8.0	11.0	
	TOT	2012-2018	8.0	11.0	20

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	BIOMEDBRIDGES	2012-2015	10.5	13.7
	CORBEL	2015-2020	14.8	14.8
	RITRAIN	2015-2020	2.0	2.0
	EOSCpilot	2017-2019	10.0	10.0
	RISCAPE	2017-2019	2.0	2.0
	EOSC-huB	2018-2020	30.0	33.3
	ID-EPTRI	2018-2020	3.0	3.1
	RI-VIS	2019-2021	1.5	1.5
	ERIC FORUM	2019-2022	1.5	1.5
	EOSC-Life	2019-2023	23.7	23.7
	TOT	2012-2023	99.0	105.6
Legal Status	ERIC, since 2013			
In Operation since	2014			

Implementation Readiness Level and Future Outlook

ECRIN started in 2004 by connecting research facilities at multiple sites in countries across Europe and providing services for top-level clinical research. It entered the ESFRI Roadmap in 2006 and has been a Landmark since 2016. ECRIN-ERIC with 9 Members and 3 Observers, has been fully operational since 2014. ECRIN has included KPIs in the annual work plan, with appropriate metrics. ECRIN undergoes regular (every 5 years) external scientific and technical peer-review. ECRIN is involved in a portfolio of about 60 multinational clinical research projects (with a mean of 6.3 countries per trial), mostly funded by H2020 Health priority or by the Innovative Medicines Initiative (IMI), and participated in 40 infrastructure development projects, promoting partnership with investigators in various medical specialties, also establishing international cooperation. ECRIN-ERIC is preparing its ISO 9001/2015 certification, expected for Q1/Q2 2020. ECRIN-ERIC is an operational Landmark. It is assessed at **RL5**. Progress to RL6 definitely depends on integration of specialised clinical trial networks and with other RIs in the biomedical research field.

Long-term Sustainability

The ECRIN team currently includes 34 staff members of 22 nationalities (half in the core team, half working in the Member and Observer countries). In its 2019 budget the provisional revenues (EUR 5.4M) are generated by incomes from the RI activity and by the ERIC Members and Observer statutory contributions. The operation costs are evaluated at EUR 5M/year of which only about 40% is assured by the ERIC members. ECRIN promotes the structuring of pan-European investigation networks providing the scientific projects and investigation capacity to complement trial management. The **excellent science** objectives include coverage of rare disease, medical device and nutrition communities. Similar partnerships in other disease areas must be developed as well as inclusiveness of specialised clinical trials (e.g. paediatric) in order to build sustainability conditions. The direct **impact** of ECRIN is limited to the service activity provided by the distributed infrastructure, mostly through its partners. **Innovation** related access involving industrial/academia represent 25% of activity. The clinical trials assessing the safety and efficacy of new products and new indications for already authorized products (repurposing trials, 40% of activity) have an impact on citizens' health, and also enlarge the health industry market. ECRIN is independent from the health industry but provides services to multinational clinical studies that are not considered as competitive research. Comparison of authorized treatments (comparative effectiveness trials, 25% of activity) result in an improvement in healthcare strategies (with a measurable **socio-economic impact** on wellbeing and productivity) and in healthcare cost containment. The remaining activity addresses personalised medicine research. ECRIN is co-secretary of the global Clinical Research Initiative for Global Health.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The sustainability of ECRIN critically depends on it reaching a European reference role in investigator-initiated clinical trials, which must be reflected in a critical mass of membership. Concurrent infrastructure proposals of specialized clinical trials, and the national dimension of most trials, can represent a bottleneck for ECRIN to become an effective, inclusive and sustainable Research Infrastructure of broad scope. ECRIN plays a secondary role in the large IMI funded projects like c4c for the creation of a paediatric investigation network and in the ECRAID clinical investigation network on infectious diseases. ECRIN participates effectively in CORBEL, but marginally in BioMedBridges and in the EOSC-Life cluster, so the integration of the biomedical science Landscape is suboptimal. However, discussion is ongoing towards an integration with the other medical infrastructures (BBMRI and EATRIS) to provide a full-service pipeline for health innovation and for personalised medicine research. Availability of funding for multinational trials clearly represents a limiting factor for ECRIN's expansion and activity, as most of the investigator-initiated trials in Europe remain at national funding and level.

Regulations for clinical trials on medicines, on medical devices, on in-vitro diagnostics, on personal data protection have clear consequences on ECRIN activities and services.

Recommendations

- Pursue broader membership and service agreements in order to establish ECRIN as the reference RI for clinical trials in Europe providing multinational benchmarking of national practices.

- Estimate a target of number of clinical trials per year (and percentage of the total number of investigator-based clinical trials in Europe) to reach such status and devise a strategy, with milestones, to reach the goal.

- Seek internationalisation where appropriate, e.g. in rare-diseases, and in the global discussion of OECD-GSF WG on multinational cooperation in non-commercial clinical trials.

- Exploit the EOSC-Life results to set data standards in the clinical-trials also usable at national level.

- Demonstrate avenues for simplification and harmonisation of the regulation of clinical trials.

ELIXIR

HEALTH & FOOD

ELIXIR

A distributed infrastructure for life-science information

ELIXIR unites Europe's life science organisations in managing and safeguarding the increasing volume of data being generated by publicly funded research. It coordinates, integrates and helps sustain bioinformatics resources across its Member States and enables users in academia and industry, wherever they are based, to access services that are vital for their research.

Typology RI	Distributed
Lead Country	UK
Members	BE, CH, CZ, DE, DK, EE, EL, ES, FI, HU, IE, IL, IT, LU, NL, NO, PT, SE, SI, UK, (EMBL-EBI)
***Observer (ERIC)**	CY
Prospective Members	FR
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ELIXIR	2007-2012	4.5	5.9	
	TOT	2007-2012	4.5	5.9	NA
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ELIXIR-EXCELERATE	2015-2019	19.0	19.0	
	TOT	2015-2019	19.0	19.0	NA
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	EMBRIC	2015-2019	9.0	9.0	
	ENVRI PLUS	2015-2019	14.7	15.0	
	CORBEL	2015-2020	14.8	14.8	
	EOSC-huB	2018-2020	30.0	33.3	
	EOSC-Life	2019-2022	23.7	23.7	
	TOT	2012-2023	102.7	109.5	
Legal Status	ELIXIR Consortium Agreement, since 2013				
In Operation since	2014				

Implementation Readiness Level and Future Outlook

ELIXIR is an ESFRI Landmark and has been on the roadmap since 2006. It currently operates under the ELIXIR Collaboration Agreement. The future legal structure is currently being reviewed including consideration of the suitability of an ERIC. The ELIXIR-EXCELERATE Final review concluded that: 'ELIXIR has become a fully operational infrastructure supporting basic and translational research and helping with global challenges related to human health, food safety, biodiversity, bio economy and more'. ELIXIR is providing data to users with open data access under basic FAIR principles and is the leading partner in the EOSC-Life project. ELIXIR includes 22 members (21 countries and one intergovernmental organisation) and one Observer, bringing together over 220 research organisations. ELIXIR is assessed as being at **RL5**. Based on its advanced science services and clustering activities, ELIXIR is considered to be moving towards RL6.

Long-term Sustainability

ELIXIR published a Long-term Sustainability Plan in 2019. This plan, which is in line with the recommendations of the 2017 European Commission Staff Working Document, sets out actions in order to support the sustainability and long-term funding of ELIXIR's activities, particularly ELIXIR Nodes and the services they run. ELIXIR is in the business of enabling **scientific excellence** by providing data and services to a wide community of users. ELIXIR has published its second 5-year Scientific Programme, which will cover the period from 2019 to 2023. Given that bioinformatics resources are typically free and open, the number of ELIXIR users and the number of scientific papers citing ELIXIR resources are not easily available. A recent effort to estimate user numbers has been carried out for a subset of ELIXIR resources (namely the Core Data Resources), which showed that user numbers were in the hundreds of thousands per month (3 million IP addresses) in 2017, almost double the estimate of 2013. Also, in 2017, there were more than 51,000 mentions of these resources in open access papers, up by a third compared to 2013. It would be useful to see updated numbers along with growth trends for other resources apart from databases. Regarding **attracting and training the managers operators and users of tomorrow**, attracting and retaining skilled staff is a challenge for the many technical roles within ELIXIR (such as computer scientists, software engineers, web developers, etc). Clearly work needs to be done in the ELIXIR Board to encourage Members of ELIXIR to address this important aspect of sustainability within the Nodes they support. ELIXIR runs a Training Platform covering all ELIXIR Member States, which includes among its aims the training and empowerment of researchers to use ELIXIR's services and tools. ELIXIR's approach to a training catalogue is being considered by others. Regarding **innovation potential,** industry is a major user of bioinformatics resources, and dedicated industry support programmes have been established by ELIXIR to support industry users and hence improve the uptake of ELIXIR services. An issue noted by ELIXIR is that when it comes to unlocking ELIXIR's innovation potential, there is a shortage of suitable funding opportunities to take forward innovative uses of RIs. ELIXIR has recently established the ELIXIR Bioinformatics Suppliers Forum, funded under ELIXIR-EXCELERATE. Rather than seeking to jointly procure services, the forum provides a platform for industry and ELIXIR Nodes to discuss the challenges and bottlenecks in the provision of bioinformatics services. ELIXIR states that, in common with other distributed, open-access RIs, assessment of **socio-economic impact** is challenging and requires expertise and availability of funding. While this may be true, such assessments are important when making the case for future investment and efforts should be made to carry out such assessments at some level and ELIXIR is a member of the RI-PATHS project consortium that aims to develop a framework describing the socio-economic impact of Research Infrastructures.

Major Bottlenecks and Possible Measures Which Might impact Further Development

ELIXIR operates under a mixed funding model with funding for the Hub coming from annual contributions from Member States plus external funding from, for example, the EU. The Node activities tend to be supported by funding from the Hub, short-term competitive grants plus national roadmap funding and other sources including EU Regional Funds. The current legal framework of the RI provides long-term stability in terms of continued Membership but the short-term nature of the Node funding remains a bottleneck.

Recommendations

- ELIXIR should make easily available, user numbers as well as numbers of papers that cite data provided through ELIXIR Nodes.
- The ELIXIR Board should encourage members to address issues relating to the recruitment and retention of skilled staff.
- ELIXIR should continue to work with the RI-PATHS project and should consider setting aside resources to carry out a socio-economic impact study specifically aimed at the impacts of ELIXIR.
- ELIXIR should promote the dissemination of information on scientific and socio-economic impact among member states to support efforts towards securing long-term funding for the ELIXIR Nodes.

EMBRC ERIC

HEALTH & FOOD

EMBRC ERIC

European Marine Biological Resource Centre

EMBRC is a multi-disciplinary Research Infrastructure for Environment and Food & Health, addressing a very important area of large-scale marine science in Europe on marine biodiversity, ocean health, and climate change, and with significant socio-economic impact potential, promoting the development of blue biotechnologies by supporting fundamental and applied research activities in medicine, nutrition, aquaculture, biotechnology, and fisheries, among others. EMBRC offers services to users from academia, industry, technology and education in all sectors in the fields of marine biology and ecology, particularly supporting the development of blue biotechnologies.

Typology RI	Distributed
Lead Country	FR
Members	BE, EL, ES, FR, IL, IT, NO, PT, UK
***Observer (ERIC)**	
Prospective Members	
ESFRI Roadmap Entry	2008
ESFRI Landmark	2018

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EMBRC-PP	2011-2014	3.9	5.3	
	pp2EMBRC	2015-2016	1.0	1.0	
	TOT	2011-2016	4.9	6.3	4.9
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ASSEMBLE Plus	2017-2021	10.0	10.0	
	TOT	2017-2021	10.0	10.0	92
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	ENVRI	2011-2014	3.7	5.1	
	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	EMBRIC	2015-2019	9.0	9.0	
	ENVRI PLUS	2015-2019	14.7	15.0	
	CORBEL	2015-2020	14.8	14.8	
	RI-VIS	2019-2021	1.5	1.5	
	ERIC FORUM	2019-2022	1.5	1.5	
	EOSC-Life	2019-2023	23.7	23.7	
	TOT	2011-2023	79.4	84.3	

Legal Status	ERIC, since 2018
In Operation since	2017

Implementation Readiness Level and Future Outlook
EMBRC entered the ESFRI Roadmap in 2008 and became a Landmark in 2018. It has been an ERIC since 2017. EMBRC was built on Integration Access projects under FP7 and H2020, and is now its Operation Phase, with 9 MS/AC members, a General Assembly (GA) composed of a scientific and political representatives of each member country, a headquarters management team and a Scientific and Innovation Advisory Board. All nodes are now reviewing their service offer and relevant expertise, engaging with their national governments to work on positioning the node as a national infrastructure, and to create incentives through national funding for scientists to use the RI. EMBRC is assessed at **RL5**. The outcomes of the current clustering projects will define the trajectory towards RL6.

Long-term Sustainability
Operation costs have been evaluated at EUR 11.2M/year, which is a factor 10 higher than the assured yearly contribution of members as established by the ERIC. A pay per access model is expected to cover the costs, although incentives to fund users will be actively seeked. So far, seven out of nine EMBRC nodes have been successful in obtaining **funding** to provide new services, demonstrating the strong involvement of the nodes and the commitment of the Member States. The EMBRC core budget is dedicated to improving coordination amongst services, such as bio-prospecting and long-term observation. Expansion of the ERIC is being explored with Baltic and Black Sea Countries. In terms of **scientific excellence** EMBRC covers a range of important topics, e.g cryo-banking of marine organisms with robust methodologies, functional genomics for several marine models, genomics observatory, standardisation of infrastructures for on-site experimental marine biology and ecology. EMBRC's emerging technologies for diving-based science delivery have a high potential to contribute to Europe's grand challenges from energy, food, security, human health, climate change to environmental degradation. Nevertheless, EMBRC's offer of research resources and services is still far from being saturated by its reference communities. The innovation potential is highest at regional level where the nodes represent assets for SMEs of the smart specialisation sector, but incentives are needed to **foster an effective access and usage** of the research services. LTS is linked to the strengthening of the user community, both academic and industrial. Outreach actions in the framework of EC projects do address the internationalisation perspective. EMBRC is also facing the general shortage of scientifically skilled science managers and operators of the RIs to expand its staff.
Major Bottlenecks and Possible Measures Which Might impact Further Development
EMBRC suffers from under-utilisation. Bottlenecks in reaching full exploitation derive from the difficult acceptance, by the academic research world, of a pay-for service model - in spite of its cost-effectiveness - and from the lack of incentives to use the infrastructure by SMEs. Improved communication with users and authorities must convey the message that using the unique EMBRC infrastructure's services to carry out advanced research is a better option than the duplication of instruments at academic level.

Recommendations

- Improve evidence-based communication of the effectiveness of EMBRC for state-of-the-art advanced research.
- Explore the possibility of linking data and services to e-infrastructures in the field, e.g. Lifewatch.
- Refine the offer of scientific services and communicate effectively the advantages of using the RI, both for academic and industrial research. Establish a few high-level external milestones.
- Enhance liaison among the nodes to develop a stronger scientific and economic offer and develop attractiveness for integrating all major European marine research stations.
- Develop a clear HR development plan to address the issues of staff development and retention.
- Pursue full European coverage.

EMFL

PHYSICAL SCIENCES & ENGINEERING	
	EMFL **European Magnetic Field Laboratory**
EMFL is a distributed, large-scale open access Research Infrastructure that acts as an umbrella organisation for three national high magnetic field facilities - HLD Dresden in Germany, HFML in the Netherlands and LNCMI in France.	

Typology RI	Distributed				
Lead Country	FR, DE, NL				
Members	FR, DE, NL, PL, UK				
***Observer (ERIC)**					
Prospective Members					
ESFRI Roadmap Entry	2008				
ESFRI Landmark	2016				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EMFL	2011-2014	4.0	6.5	
	TOT	2011-2014	4.0	6.5	NA

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				NA
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	EUROMAGNET II	2009-2013	7.5	10.8	
	TOT	2009-2013	7.5	10.8	
Legal Status	AISBL, since 2015				
In Operation since	2017				

Implementation Readiness Level and Future Outlook
EMFL entered the ESFRI Roadmap in 2008 and became a Landmark in 2016. EMFL was set up as an AISBL in 2015 and the three partner countries fund the running costs of about EUR 20 million/year. The laboratories have been included in the French and Dutch national roadmaps. EMFL provides a high-level service to a broad community of users and is deemed to be competitive on the world stage. It is currently assessed as being at **RL5**. Progression to RL6 will likely require a major upgrade.

Long-term Sustainability

The 2015 ESFRI Implementation Group (IG) report recommended that EMFL move from a coordination mechanism to a more integrated RI by simplifying their **governance and management** framework. The ERIC instrument is being considered but EMFL believe that their current management structure adequately supports operations and ensures good service provision. The IG report also recommended that new members should be brought in to address potential financial shortfalls and to increase the overall capacity of the RI. Three new members have been secured since 2015 (Poland, UK, CEA) who now contribute to the running costs. With regard to current **scientific excellence**, the 2018 annual report indicates that the research performed in EMFL facilities had resulted in more than 170 peer-reviewed publications. There are two open calls for access per year which are clearly visible from the website and applications are assessed on scientific excellence. As part of its **service-driven approach**, an annual User Committee meeting has been introduced to assess users' needs and ways in which EMFL might be improved. This effort seems to be paying off as the 2018 annual report indicates that the requests for magnet time had increased to a new record number of 361 proposals. EMFL aims to support the provision of FAIR data and has a well-developed **data policy**. EMFL state that while the modest levels of data generated can be easily stored and made accessible, metadata management is proving more challenging. EMFL is currently developing a common **data management plan** for EMFL facilities which should address this issue. In addition to **training users of tomorrow**, EMFL holds bi-annual **staff development** meetings (EMFL Days) to bring scientific, technological and administrative staff together to learn more about each other's work across the different sites, exchange ideas, and define a common strategy for the future of EMFL. Short and medium-term staff exchanges are also supported. EMFL doesn't currently see **industry** as end users of the RI but industry gains a competitive advantage from collaboration with EMFL on the development of advanced instrumentation. EMFL recently introduced Open Days which have been well attended so far and should help to demonstrate the potential **impact** of the RI to the general public. In terms of **international** outreach, EMFL currently chairs the High Field Forum (HiFF) network that unites high field facilities worldwide and provides opportunities for collaborations with facilities outside of Europe.

Major Bottlenecks and Possible Measures Which Might impact Further Development

There has been recent investment to support upgrades which should keep EMFL globally competitive for the coming years. However, the rising costs of energy and the costs of next generation high field magnets are challenges facing the RI in the future. In this respect, EMFL will require investment that goes beyond what can be obtained at the national level. EMFL recognise that the AISBL will not be the best vehicle for ensuring the levels of financial support needed for a major upgrade and that a different structure may be necessary in the future (such as the ERIC). There is a dedicated work-package in the recent INFRADEV-03 ISABEL project proposal to investigate governance structures. The 2015 IG report recommended that EMFL develop a medium-term financial plan with a draft budget specifying in-kind contributions and secondments. The latest EMFL annual report does not provide any financial information so it is difficult to assess whether the RI operational costs are in line with income streams in support of longer-term financial sustainability.

Recommendations

- To secure the needed funding to provide next generation high field magnets, EMFL should seek to establish a more centralised governance structure (ERIC or similar) identifying possible instruments to take this activity forward.

- If there is scientific support for the next generation high field magnet upgrade, there may be potential to seek a new Preparatory Phase to address the related financial, technical and governance aspects.

- It may be beneficial for EMFL to seek to cooperate informally with one or both of the physical sciences and engineering cluster projects (PaNOSC, ESCAPE) as the RI develops its data management plan - particularly with regards to supporting the provision of access to FAIR data.

- It is recommended that EMFL make its financial information more transparent as part of its annual reporting and provides clarity on levels of external usage and how these can contribute to required upgrades over time.

EMPHASIS

HEALTH & FOOD	
	EMPHASIS **European Infrastructure for Multi-Scale Plant Phenotyping and Simulation for Food Security in a Changing Climate**

European Infrastructure for Multi-Scale Plant Phenotyping and Simulation for Food Security in a Changing Climate (EMPHASIS) aims to develop and provide access to facilities and services that address multi-scale plant phenotyping in different agro-climatic scenarios in Europe. Once established, it will offer a European phenotyping infrastructure to analyse genotype performance under diverse environmental conditions and quantify the diversity of traits contributing to performance in these diverse environmental scenarios such as plant structure and architecture, major physiological functions and output, yield and its components and quality.

Typology RI	Distributed				
Lead Country	DE				
Members					
***Observer (ERIC)**					
Prospective Members	BE, EE, FR, DE, IL, IT, RS, CH, NL, UK				
ESFRI Roadmap Entry	2016				
ESFRI Landmark					
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EMPHASIS-PREP	2017-2020	4.0	4.0	
	TOT	2017-2020	4.0	4.0	4.0

<table>
<tr><td rowspan="3">Implementation/ Construction</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>TOT</td><td></td><td></td><td></td><td>73.0</td></tr>
<tr><td rowspan="10">Collaborative Grants

Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td colspan="2">EUR M (Total)</td></tr>
<tr><td>ENVRI</td><td>2011-2014</td><td>3.7</td><td colspan="2">5.1</td></tr>
<tr><td>ERACAPS</td><td>2011-2015</td><td>2.0</td><td colspan="2">2.2</td></tr>
<tr><td>EPPN</td><td>2012-2015</td><td>5.5</td><td colspan="2">7.2</td></tr>
<tr><td>ENVRI PLUS</td><td>2015-2019</td><td>14.7</td><td colspan="2">15.0</td></tr>
<tr><td>CORBEL</td><td>2015-2020</td><td>14.8</td><td colspan="2">14.8</td></tr>
<tr><td>EPPN2020</td><td>2017-2021</td><td>10.0</td><td colspan="2">10.2</td></tr>
<tr><td>RI-VIS</td><td>2019-2021</td><td>1.5</td><td colspan="2">1.5</td></tr>
<tr><td>EOSC-Life</td><td>2019-2023</td><td>23.7</td><td colspan="2">23.7</td></tr>
<tr><td>TOT</td><td>2011-2023</td><td>75.9</td><td colspan="2">79.7</td></tr>
<tr><td>Legal Status</td><td colspan="5">Pending</td></tr>
<tr><td>In Operation since</td><td colspan="5">Foreseen 2021 (Currently in Preparatory Phase, ESFRI Project)</td></tr>
</table>

Implementation Readiness Level and Future Outlook

EMPHASIS is a distributed Research Infrastructure with headquarters in Jülich, DE and Montpellier, FR. it has been an ESFRI Roadmap Project since 2016. It entered the Implementation Phase in 2019 and plans to become operational in 2021. Still in the Preparatory Phase, EMPHASIS is assessed at **RL2**. The progress to the next RL requires a financial analysis (including the discounted cash-flow analysis), a cost-book, and a robust plan of contributions for the full construction and early operation of the RI. Some elements of higher RLs are already addressed via EU-funded projects where EMPHASIS consortium members are participating.

Long-term Sustainability

EMPHASIS is in the Preparatory Phase with the key focus of developing a business plan covering the scientific potential, usage, governance, sustainable financing, economic efficiency and social significance. EMPHASIS aims at bringing solutions on how 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, which is an extremely important practical application with high potential for **societal impact.** The focus on **scientific excellence** is less articulated. However, establishing and providing access to cutting-edge facilities should enable science not possible before and lead to excellence. A list of research facilities and capabilities – as a starting point – is available via EPPN2020 (an ongoing European Plant Phenotyping Network's project). This constitutes only one of the five infrastructure's pillars (i.e. controlled environment facilities) of the future EMPHASIS offering, which will also cover intensive field sites, networks of field sites, modelling platforms, and pan-European information system. EPPN2020 also assures actions to **attract and train users** "at all career levels". The EMPHASIS Management Team has benefited from training under both EPPN2020 and RItrain. A long list of companies is mentioned in the EMPHASIS website as industrial support, but it does not specify what kind of support is provided. The plan is to reflect and expand this dimension as part of the **innovation** strategy, to be finalised by the end of the Preparatory Phase project. The topic of **socio-economic impact** is only generically mentioned in the project's work packages. EMPHASIS put efforts in developing centralised FAIR **data management** and access as well as the information system, building on the EPPN2020 activities. It contributes to the MIAPPE (Minimum Information about a Plant Phenotyping Experiment) initiatives and discusses with ELIXIR the respective roles and common tasks. The **international outreach** is secured via the International Plant Phenotyping Network (IPPN) and is being further expanded through the H2020 RI-VIS project, the G20 wheat initiative as well individual recognition of the leading scientists from EMPHASIS in national plant phenotyping centres outside Europe. The planned **governance** structure follows a "standard" model with a central coordinating hub and national nodes and an "interim agreement to enable implementation" to be reached during the Preparatory Phase. Further work towards national commitment beyond in-kind contributions should follow in order to ensure sustainability. Two ministerial meetings in 2019 involved representatives from 11 countries "to initiate the first steps towards service provision and funding, in parallel to the development of a legal framework". Although such a non-binding commitment does not guarantee future funding, discussions on possible legal framework are taking place.

Major Bottlenecks and Possible Measures Which Might impact Further Development

EMPHASIS has close links and builds on the activities of EPPN the EPPN2020 project, and is now expanding to a broader membership. The complementarity with other well-established Research Infrastructures such as ELIXIR and AnaEE is described, but the need for a separate Research Infrastructure is nevertheless not clear. The added value of the RI compared to the network of facilities as covered by EPPN2020, which involves the same community and partners, is not yet focussed. Overall, it is great to see the involvement of EMPHASIS as an early-stage RI in other ongoing projects linking together several RIs thematically (like CORBEL or ENVRIplus) or setting to address specific questions (like EOSC topics in relation to life sciences RIs as in EOSC-Life, or visibility of RIs, as in RI-VIS). Assuming that the same organisations and people are involved in these various projects implies that an optimisation of time and efforts on the key activities (i.e. growing memberships and crystallising the value added) must be assured to limit the risk of delayed implementation.

Recommendations

- As an outcome of the preparatory project, prepare a strong case justifying building a distributed RI instead of continuing via an existing EPPN or integrating some of the activities into an already well-functioning and thematically connected RI. The case should be supported by a clear business plan that will lead to the growth in membership and funding.

- Regardless of the route taken, prepare a staff exchange plan within thematically linked infrastructures and networks and develop a model for sustainable trans-national access.

- Make services of the EPPN facilities visible and accessible through the catalogues of services at CORBEL and EOSC. All these should be more beneficial if done as part of the EPPN rather than a newly created Research Infrastructure. Acknowledging that EPPN was a project which ended in 2015, it should undoubtedly still be in place as a network which participants still have common scientific interest.

- Build on experience from other ESFRI Landmarks, e.g. ELIXIR, in getting their best practice on engagement with industry and knowledge and technology transfer. Prepare and disseminate clear examples from the EPPN activities in utilising the research facilities.

- Show how excellence driven mode of access to the facilities will be assured and lead to scientific excellence.

- To further build on ensuring scientific excellence, EMPHASIS should set itself as a RI a list of key performance indicators to be monitored as part of the governance, which can build on the involvement in various related activities.

EMSO ERIC

ENVIRONMENT	
	EMSO ERIC **European Multidisciplinary Seafloor and water-column Observatory**
EMSO is a European Research Infrastructure in the field of marine sciences, composed of a network of automatic systems for monitoring distributed in the seas around Europe. It is composed of 8 underwater cabled and standalone observatories at key environmental sites, set up at great depths, and 3 cabled test sites in shallow waters, that provide large data flows and monitor the environmental processes affecting the geosphere, the biosphere and hydrosphere and their interactions. This system enables the collection of valuable data on natural hazards, climate change and marine ecosystems.	

Typology RI	Distributed
Lead Country	IT
Members	EL, ES, FR, IE, IT, PT, RO, UK
***Observer (ERIC)**	
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EMSO	2008-2012	3.9	5.4	
	TOT	2008-2012	3.9	5.4	5.4
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EMSODEV	2015-2019	4.3	4.5	
	EMSO-Link	2017-2020	4.4	4.4	
	TOT	2015-2020	8.7	8.9	137.8
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ENVRI	2011-2014	3.7	5.1	
	ENVRI PLUS	2015-2019	14.7	15.0	
	ENVRI-FAIR	2019-2022	19.0	19.0	
	ERIC FORUM	2019-2022	1.5	1.5	
	TOT	2011-2022	38.9	40.6	
Legal Status	ERIC, since 2016				
In Operation since	2016				

Implementation Readiness Level and Future Outlook

EMSO developed during twenty years of work first on seafloor observatories with multi-disciplinary capabilities and then on networking them and developing the RI concept. EMSO entered the ESFRI Roadmap in 2016. EMSO was also established as ERIC in 2016, with eight members and was included as a Landmark in the ESFRI Roadmap of 2016. Two INFRADEV-3 projects focussed respectively on technological development and service provision plus governance, are coming to completion soon. EMSO is still transitioning towards full operations, which are foreseen to be fully deployed in 2022. EMSO is assessed as being at **RL5**. If the challenges in consolidating the full operation phase are met, EMSO has good prospects of progressing towards RL6 when compliance with FAIR principles for data and services (as will be defined by the EOSC) are achieved.

Long-term Sustainability

EMSO ERIC has a defined **governance structure** and a financial plan (and statements) in place. However, **KPIs** and the cost breakdown structure are only accessible, on demand, at the end of each fiscal year, therefore, not really publicly available. There is a need for ERIC proactive coordination to address the weakness of the highly fragmented scenario at national levels and within the hub. Effectively addressing this European fragmentation would enable the alignment of the state-of-advancement of the different EMSO ERIC nodes and encourage additional Member States to become full members.

An additional mission goal is to ensure transparent and equitable access to scientific results, data, and related services, with clear rules on the rights and obligations concerning IP for researchers from Members of the EMSO ERIC, as well as for researchers from countries which are not participating in the ERIC yet. In fact, EMSO aims at developing value added **data** products that are expected to serve a broad range of interdisciplinary users. Identifying **value-added services** for the community, establishing Service Groups, defining a strategy for data access, design and implementing an EMSO Label are essential activities to reinforce. The limited communication among different sectors and levels, as well as the needs of specific approaches to work with several different national operators, are slowing down the processes. **Scientific excellence** is pursued through **international cooperation** by: strengthening links with all main global Ocean and Oceanfloor observatories; enacting MoUs with environmental European RI´s, such of those working with LifeWatch, EMBRC, under discussion with ICOS, and global sister marine observatory initiatives, such as the one in force with ONC Canada aiming at building a healthy level of integration and providing seamless virtual access to and preservation of data, services for connectivity, computing resources, data storage and management to guarantee **interoperability**.

EMSO has an inherent **innovative** value with potential to contribute to economic growth in the marine SME sector and in information and communication technologies. The transnational access programme is in place, but no general **access policy** for all users is publicly available. The measurement of **socio-economic impact**, through periodic monitoring of societal impact and the development of socio-economic impact assessments, is also not available, hampering the capability of EMSO to motivate the participation of new MS/AC.

The required organizational profiles and **training** needs of the managers of EMSO, their roles and responsibilities within the management structure, is not clearly addressed and EMSO should invest in its **human capital** enhancing employee capabilities, knowledge, motivation, and empowerment, thus reinforcing the key intangible assets for the RI.

Major Bottlenecks and Possible Measures Which Might impact Further Development
Fragmentation of resources in the nodes and under-utilisation of the workforce are bottlenecks for the development of EMSO that must foster the creation of stronger linkage to the hub. Lack of harmonisation and synchronisation of policy programming at the regional, national and European levels of medium and long-term investments strategies are a bottleneck for EMSO. An additional bottleneck is the need for a clearer strategy to unlock the innovation potential needed for EMSO to become sustainable in the longer term. This sustainability concept should include a coherent mapping of the regional (RIS3) and maritime innovation ecosystem, as well as roadmaps to promote the key technologies/services of EMSO and generate the interest and the engagement of industrial research and industrial partners.
Recommendations
• EMSO should define an innovation strategy and implement a stakeholders' forum in order to identify and implement specific services to the scientific and industrial communities • Reinforce the governance with a reliable performance and risk measuring system to serve as RI control. • Formulate an adequate and consistent access policy to the Research Infrastructure data and services • Enhance collaborations with other e-RIs, such as LifeWatch, EMBRC and ICOS to develop state-of-the-art e-infrastructures focusing on interoperability • Clarify IP and access policy plans • Design a multi-annual Human Resources development plan for EMSO ERIC staff as well as end-users • Develop and monitor social-economic impact and scientific KPIs accomplishment.

EPOS ERIC

ENVIRONMENT

EPOS ERIC

European Plate Observing System

EPOS is the overarching European RI for solid Earth science aimed at providing virtual access to data, products and services and physical access to facilities serving all research efforts in the domain of geology, seismology, geodesy, volcanology, geomagnetism as well as chemistry and physics of rocks and magmas, in connection with the global issues of maintaining the Earth a safe, prosperous, and habitable planet. Its services are based on the integration of data from the ensemble of observing systems and facilities operated, mostly at national level, by scientific institutions and built for the monitoring and the surveillance of the territory from natural and anthropogenic phenomena.

Typology RI	Distributed
Lead Country	IT
Members	BE, DK, EL, FR, IS, IT, NL, NO, PL, PT, SI, UK
***Observer (ERIC)**	CH
Prospective Members	
ESFRI Roadmap Entry	2008
ESFRI Landmark	2018

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EPOS	2010-2014	4.5	6.3	
	TOT	2010-2014	4.5	6.3	4.5
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EPOS IP	2015-2019	18.4	31.0	
	TOT	2015-2019	18.4	31.0	32
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ENVRI	2011-2014	3.7	5.1	
	COOPEUS	2012-2015	2.0	2.3	
	ENVRI PLUS	2015-2019	14.7	15.0	
	ENVRI-FAIR	2019-2022	19.0	19.0	
	ERIC FORUM	2019-2022	1.5	1.5	
	TOT	2011-2022	40.9	42.9	
Legal Status	ERIC, since 2018				
In Operation since	Foreseen 2020 (Currently in Implementation Phase, ESFRI Landmark)				

Implementation Readiness Level and Future Outlook

EPOS is an ESFRI Landmark and has been on the roadmap since 2008. It is the comprehensive RI for the whole solid Earth science born out of different FP6 and FP7 projects and Integration actions. EPOS just entered in the Pilot Operational Phase, in which implementation, construction and operation of data and service provision to users will proceed in parallel with Strategic and Service Delivery Plans that will lead to a full sustainable operation by 2022. In 2014 EPOS was assessed by ESFRI as one of the three priority projects for implementation. The central hub of the Integrated Core Services (ICS-C) will provide access to data, products and services from the federated Thematic Core Services (TCS, the community framework where data, products and services are generated); a prototype version of the ICS-C has been validated and tested for interoperability and FAIR data management. The ICS-C will be hosted in the UK (UKRI-BGS) and France (BRGM), with technical support from Denmark (GEUS), all providing a host premium for this key component of the EPOS RI. Italy is providing the host premium for the legal seat. The capital value of all national infrastructures contributing to EPOS is EUR 500M. The Thematic Core Services will federate the scientific communities of Seismology, Near-Fault Observatories, GNSS Data & Products, Volcanoes Observations, Satellite Data, Geomagnetic Observations, Anthropogenic Hazards, Geological Information and Modelling, Multi-Scale Laboratories. Two further communities of Geo Energy Test Beds and Tsunamis Data and Modelling will be federated in 2020. The operation costs are estimated at EUR 18 Million/year from 2020 onward. It is assessed as being at **RL4**. RL5 will be reached as operation starts. EPOS is participating to the cluster ENVRIFAIR to share IT solutions and foster e-science innovation on data interoperability and preservation.

Long-term Sustainability

The LTS of EPOS ERIC relies on strengthening the financial viability and building a sustainable delivery framework. Critical elements are: i) strengthening financial viability by enlarging ERIC membership and including in-kind contributions from national initiatives; ii) continuous innovation and technical sustainability of EPOS core services (thematic and integrated); iii) engaging new communities and converge to EPOS readiness and advanced FAIR compliance; iv) cooperate with the private sector; v) globalisation. The sustainability of the EPOS Delivery Framework implies solving legal and financial issues in order to allow EPOOS ERIC to financially contribute to the data and services generated outside the ERIC perimeter through legal agreements and a manageable reporting/auditing framework. Harmonisation of the national priorities with the EPOS federation strategy is also a key element of financial sustainability as well as the effective data integration, harmonisation and quality management operated by the Thematic Core Services. The **socio-economic impact** is also represented by the societal and economic added value for users, including the industrial and economic sector, of data and service provision. The **scientific excellence** will be ensured by constantly upgrading data repositories and EPOS services, enabling the access to scientific products not available otherwise for a wide user community. The **innovation** potential of EPOS lies in sharing progress in data science and FAIR data management also through the engagement of users to become data products providers. The EPOS added value for society may include fostering a culture of prevention from natural and anthropogenic disasters, a substantial but hardly tangible asset for socio-economic impact. Sustainability of the whole data production chain of EPOS relies on dynamical standardisation of good practices, feeding back to the sustainability of the RI-chain of providers as a whole. The financial needs require a mixture of direct funds to the ERIC and national in-kind contributions within and outside the ERIC perimeter. The construction of the EOSC federated infrastructure should reflect back to EPOS service sustainability, by optimising cost and time involved in FAIR data and interoperable infrastructure deployment.

Major Bottlenecks and Possible Measures Which Might impact Further Development
EPOS costs nearly EUR 18M per year for the operation of the federated RI. A 25% quota (EUR 4.4 M) of this cost is envisioned to be covered by the ERIC subscriptions as established for the first 5 years. The LTS issue has, therefore, a main component that is outside the perimeter of the EPOS ERIC, concerning the Thematic Core Services where data are generated. One bottleneck concerns the ERIC hurdles for establishing a suitable legal and financial framework (through Cooperation Agreements) outside of the ERIC perimeter in terms of funding, VAT exemption, reporting and auditing. Internationalisation and outreach also depend on international cooperation policies. Missing a long-term structure of EU support to ERICs for pan-European benefits is a bottleneck, making further integration of new communities under the sole governance of the ERIC difficult.
Recommendations
• Expand the membership of EPOS-ERIC assuring a larger fraction of operational costs. • Constantly upgrade the interoperability uniqueness and reliability of services, assuring the quality of the new data-sets and time-series of solid Earth science data. Pursue a dynamic standardisation of good practices, feeding back to the sustainability of the RI-chain of providers as a whole by adding value of the data sets owned by the different organisations. • Provide quality certified wide access and customer-tailored Thematic and Integrated services, with a standardized cost, uniform throughout the EU and opened to others. • Implement the domains of geo-hazard and geo-resources (e.g. geo-energy) that can mobilise incomes to EPOS based on personalised data and data-analysis services or co-design involving the economic customers. • Certification of Data Repositories will strengthen value for data sharing and obtain strong engagement of the data producers..

ERINHA

HEALTH & FOOD

European Research Infrastructure on Highly Pathogenic Agents

ERINHA

European Research Infrastructure on Highly Pathogenic Agents

ERINHA is a pan-European distributed Research Infrastructure with headquarters in Brussels and Paris. Its aim is to facilitate and accelerate research on highly pathogenic agents by providing a coordinated access to its members' high containment biosafety level 4 facilities and complementary research facilities and expertise.

Typology RI	Distributed				
Lead Country	FR				
Members	FR, HU, NL, PT, SE				
***Observer (ERIC)**					
Prospective Members					
ESFRI Roadmap Entry	2008				
ESFRI Landmark	2018				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ERINHA	2010-2014	3.6	4.8	
	ERINHA2	2016-2017	1.4	1.4	
	TOT	2010-2017	5.0	6.2	5.1

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ERINHA-Advance	2019-2021	3.2	3.2	
	TOT	2019-2021	3.2	3.2	0.7
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	CORBEL	2015-2020	14.8	14.8	
	RI-VIS	2019-2021	1.5	1.5	
	EOSC-Life	2019-2023	23.7	23.7	
	TOT	2012-2023	50.5	53.7	
Legal Status	AISBL, since 2017				
In Operation since	2018				

Implementation Readiness Level and Future Outlook

ERINHA is an ESFRI Landmark in its Operation Phase. It entered the Roadmap in 2008 as "European High Security BSL4 Laboratories" and from 2010 featured as ERINHA. After more than 10 years on the Roadmap, several EU-funded projects supporting numerous (often recurring) activities, and a small number of their expertise-driven activities in projects with the European Space Agency, the Coalition for Epidemic Preparedness Innovations and research institutions in Europe and the USA, few tangible results have been produced in developing ERINHA as a research infrastructure with a clear value added. Lack of clarity may explain the very slow progress of ERINHA in growing its membership, still limited to only 5 organisations from 5 countries, although AT and BE are preparing to join and negotiations with DE and CH are ongoing. The issues of finance, governance, user strategies, stakeholder engagement, and involvement of national partners were already considered as undeveloped by the 2012 EC AEG and 2015 ESFRI reviews. Progress in these areas is still required to consolidate ERINHA at **RL4** and move towards RL5.

Long-term Sustainability

ERINHA's research strategy is focused on large projects that require the capabilities of a number of research facilities (national nodes) and which are selected based on, among other things, **scientific excellence**. However, access policies beyond current free access under the TA call to facilities are not clear. A more service-driven approach neds to be developed; currently no ERINHA's services are listed in the CORBEL database (despite the involvement of ERINHA in the project since 2015 and ERINHA's inclusion in the CORBEL website). Although the Statutes talk about provision of **training** and skills enhancement for laboratory users, no coordinated training programme is promoted. The selected scientific and research focus of ERINHA makes this Research Infrastructure of **international** interest and benefit resulting in bilateral collaborations outside the EU. Activities within the ERINHA network have a potential to **unlock innovation** (as the research programme covers both collaborative and contract research) and to bring **socio-economic impacts** (as impact on health is one of the key areas of ERINHA) but a clear vision on these topics is missing. ERINHA has multiple opportunities through its involvement in several thematic and cluster projects to **exploit the data** generated by RI, but limited funding available for ERINHA in these projects is a risk. The **Governance and sustainable long-term funding** is the weakest area for long-term sustainability. Only five organisations (from five countries) are members of ERINHA AISBL despite 11 partners from 8 countries participating in ERINHA-Advance and 16 partners from 12 countries in ERINHA2. Members from AT and BE are expected to join in 2020. For such a small composition, the current governance of ERINHA is cumbersome with the Executive Board of a minimum four representatives reporting to the General Assembly involving representatives from all funding members (currently five). The current project ERINHA-Advance is set to cover all key topics of long-term sustainability, i.e. expanding its membership, international cooperation, setting up a Board of Industrial Representatives and a strategic outreach plan to target industry, strengthening the framework of ERINHA services, conducting and showcasing pilot studies for transnational access, and updating the Data Management Plan. These topics were also part of previous projects, but progress seems to have been small.

Major Bottlenecks and Possible Measures Which Might impact Further Development

With poor progress so far, the added value of ERINHA as a RI is not clear. Despite an extremely important scientific and societal application and given comparatively low (in relation to other RIs) construction (EUR 0.7M) and operation (EUR 0.7M/year) costs the lack of a clear value proposition is a bottleneck. Updating the Business Plan including targeted user involvement from industry with a clear access policy and investigating the feasibility of industry co-funded research programmes are possible actions to foster the consolidation of the RI.

Recommendations

- If substantial advancement towards fulfilling a scope of an international Research Infrastructure is not achieved during ERINHA-Advance, efforts should be reoriented towards establishing a pan-European network of facilities with specific research programmes going beyond the reliance on European calls funding research on high-risk pathogens.

- Simplify ERINHA's governance structure until the membership is bigger; the Director General should dedicate entirely to ERINHA and focus on raising funds and growing membership. To avoid a potential conflict of interest (while the membership is small) ensure that national representatives in the GA come from organisations other than the national node of that member state.

- Change the commitment from member organisations moving away from purely in-kind to substantial cash contributions; use part of funds raised to develop an in-house pan-European research programme thus bringing a clear added value of ERINHA as a RI.

- Publish a list of services in the CORBEL database as a true catalogue of services and facilities and not as a summary about ERINHA (which is also out-of-date only listing 3 member states), make transnational access guidelines easily visible and findable under the 'Services' part of the website and share examples and success stories of access to facilities as well as facilitated research projects. Work on updating the TA policy to include access modalities other than free access.

- As a way to stimulate more joint research projects, put in place a staff exchange programme between the participating facilities and, possibly, industry partners.

- Set performance indicators for the Central Coordinating Unit and Director General to ensure delivery on set aims, and report on these indicators in the annual review.

ESS ERIC

SOCIAL & CULTURAL INNOVATION	
	ESS ERIC **European Social Survey**

The European Social Survey (ESS) is an ERIC research infrastructure built to consolidate the academically driven biennial cross-national survey that has been conducted across Europe since 2001. ESS aims to chart stability and change in the social structure, conditions and attitudes in Europe and to interpret how Europe's social, political and moral fabric is changing in order to achieve and spread higher standards of rigour in cross-national research in the social sciences. The ESS questionnaire regularly addresses enduring topics through its core modules including institutional trust, life satisfaction, religion, human values, as well as attitudes towards immigration and more topics are introduced over time via an open academically led competition.

Typology RI	Distributed
Lead Country	UK
Members	AT, BE, BG, CY, CZ, DE, EE, FI, FR, HR, HU, IE, IS, IT, LV, LT , NL, NO, PL, PT, SK, SE, SI, UK
***Observer (ERIC)**	CH
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	PROJECT NAME	YEAR-YEAR	EUR M (EU)	EUR M (Total)	EUR M (ROADMAP 2018)
	ESSIE	2001-2003	1.4	1.8	
	MACE	2003-2005	1.8	2.3	
	ESS3	2005-2007	1.4	1.6	
	ESS4	2007-2010	1.7	1.7	
	ESSPREP	2008-2010	1.5	2.1	
	TOT	2001-2010	7.8	9.5	6.4
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ESS-DACE	2011-2014	5.0	6.7	
	ESS-SUSTAIN	2015-2019	2.4	2.4	
	ESS-SUSTAIN2	2020-2022	5.0	5.0	
	TOT	2011-2022	12.4	14.1	2.3

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	DASISH	2012-2014	6.0	8.3
	SERISS	2015-2019	8.5	8.9
	RITRAIN	2015-2020	2.0	2.0
	RISCAPE	2017-2019	2.0	2.0
	RI-VIS	2019-2021	1.5	1.5
	ERIC FORUM	2019-2022	1.5	1.5
	SSHOC	2019-2022	14.5	14.5
	TOT	2012-2022	36.0	38.7
Legal Status	ERIC, 2013			
In Operation since	2013			

Implementation Readiness Level and Future Outlook

ESS has been on the ESFRI Roadmap since 206 and became a Landmark in 2016. It became an ERIC in 2013. The ESS ERIC infrastructure allows academics to harness the highest quality cross-national data to address academic and societal challenges on a scale that would not be possible were scholars to organise those activities in isolation. In that sense the ESS is truly providing an 'infrastructure' serving disciplines across the social sciences by sharing its data freely and openly without restriction and ensuring its content is collectively shaped. Furthermore, ESS has arguably been applying the FAIR data principles before the acronym was even devised. All anonymised ESS data is made freely available for anyone anywhere in the world to download after a short and immediate registration. Over thirty European Countries have taken part in at least one round of the biennial study. About 135,000 data users are registered on the website, over 4000 academic publications have appeared based on ESS data since 2003 and tens of thousands of students learn data analysis using ESS data. The ESS ERIC is assessed at **RL5** in full operation. Progress towards RL6 will occur through clustering with other RIs.

Long-term Sustainability

The funding model of ESS includes a basic fee plus a GDP related contribution for all member countries, apart from those with the smallest GDP, securing stability. Increased membership and guest participant status have contributed to reinforcement of the budget. Insisting on monetary contributions and avoiding contributions in kind, highly professional accounting and audit procedures and detailed planning and execution of General Assembly meetings have strengthened the operation of the ERIC. ESS was awarded the Descartes Prize and its **scientific excellence** was assessed in 2008, and continuously proved by the publication track record. A range of non-academic **impacts** based, in part, on ESS data includes as examples of **innovation** and **socio-economic impact,** the use of ESS intelligence for policymaking at the Austrian Ministry of Social Affairs; increased global cooperation for monitoring health inequalities in Norway and improved training of judges and support for reforms of the judiciary in Portugal. FAIR data production is practiced, building on EOSC readiness. **Attracting and training managers and operators of tomorrow** is a challenge as insofar the ESS model relies on linked third parties, mostly academic, for human resources. On the other hand being an academically led RI being located in academic institutions, offers other advantages. ESS has arranged its own internal scientific review with its Methods Advisory Board and Scientific Advisory Board to review current practices and help it prepare for the future.

Major Bottlenecks and Possible Measures Which Might impact Further Development
ESS needs to reach full coverage of the EU and wider ERA. For some non-EU potential partners the ERIC status is perceived as not flexible enough. Implementing ESS fieldwork in each country has become increasingly challenging as response rates decline, costs of fieldwork rises, and the number of suitable data collection providers reduces. ESS national teams receive differing levels of support and remuneration from national funders resulting in somewhat differential compliance with ESS standards. Addressing those issues will be crucial to ensuring positive future prospects for ESS. The ESS ERIC has no staff of its own which makes it difficult to train, remunerate and retain management and operators over a sustained period. A design study is being prepared with other social science RIs (CESSDA ERIC, SHARE ERIC, as well as GGP and EVS) to take that work to a future proofing level with the design of a new RI which will provide scientific data collection services to existing and future social science infrastructures. This along with the extension of the SERISS results towards the capability of moving data collection on-line in 12 countries under the ESS-SUSATIN-2 award, prepares for the upgrade to RL6. Commission funding in the form of INFRADEV and CLUSTER type support remains critical to complement member state support.
Recommendations
• Actively pursue the goal of full coverage of European Countries and beyond • Pursue integration with the SCI/SSH RI ecosystem • Pursue LTS of survey rounds and FAIR data contribution to EOSC • Develop an ERIC strategy to ensure training and recruiting at proper level of managers and officers of the RI, perhaps in combination with the pan-SCI/SSH RL& model infrastructure

EU-OPENSCREEN ERIC

HEALTH & FOOD

EU-OPENSCREEN ERIC

European Infrastructure of Open Screening Platforms for Chemical Biology

EU-OPENSCREEN is a distributed Research Infrastructure that develops novel small chemical compounds as 'probes' or research tools which elicit specific biological responses on organisms, cells or cellular components. EU-OPENSCREEN enables scientists to use compound screening methods to validate novel therapeutic targets and support basic mechanistic studies addressing fundamental questions in cellular physiology – across human, animal and plant systems – using the methods of chemical biology.

Typology RI	Distributed				
Lead Country	DE				
Members	CZ, DE, ES, FI, LV, NO, PL				
***Observer (ERIC)**					
Prospective Members					
ESFRI Roadmap Entry	2008				
ESFRI Landmark	2018				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EU-OPENSCREEN	2010-2016	3.7	5.0	
	TOT	2010-2016	3.7	5.0	4.3

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EU-OPENSCREEN-DRIVE	2019-2023	5.0	5.0	
	TOT	2019-2023	5.0	5.0	6.2
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	EMBRIC	2015-2019	9.0	9.0	
	iNEXT	2015-2019	10.0	10.0	
	CORBEL	2015-2020	14.8	14.8	
	RI-VIS	2019-2021	1.5	1.5	
	ERIC Forum	2019-2022	1.5	1.5	
	EOSC-Life	2019-2022	23.7	23.7	
	iNEXT-Discovery	2020-2024	10.0	10.0	
	TOT	2012-2024	81.0	84.2	
Legal Status	ERIC, since 2018				
In Operation since	2019				

Implementation Readiness Level and Future Outlook EU-OPENSCREEN entered the ESFRI Roadmap in 2008 and is an ESFRI Landmark. The ERIC status was awarded in April 2018 with seven member Countries. Currently, EU-OPENSCREEN ERIC has eight members including Denmark, which was previously an observer. EU-OPENSCREEN is assessed at **RL5**.
Long-term Sustainability EU-OPENSCREEN has carried out a user demand analysis and has set up a transparent user access policy, that includes a common access portal. A list of KPIs has been agreed by the ERIC Assembly of Members and included in the Scientific and Technical Description. The detailed list of key staff and roles is available in the statutes although no costs associated with each specific role is available in the financial report (however, the HR costs are present). **Training** programmes are available for both user community and staff. The research developed is of direct interest to the private sector. However, individual co-development projects with industry partners and an 'Industry Associate Group' and 'Industry Advisory Group' are still to be implemented as part of the H2020 DRIVE project. In order to reach its full potential, EU-OPENSCREEN needs to have a comprehensive communication and dissemination plan. The ERIC central office has a dedicated Office & Communication Manager who is in charge of raising awareness about EU-OPENSCREEN. In particular, there is a need to define and monitor **socio-economic impact**, based on a periodic monitoring assessment. EU-OPENSCREEN open access policy foresees an embargo period of up to three years on screening **data** which allows IP protection for industry partners and users, making the use of archived data attractive to industry. As the ERIC status was awarded, the roles of the Strategy Officer, European Relations and Grant Officer, Scientific Project Officer and Office Manager are now in place, and a user forum will be implemented. An advanced financial plan and a sustainable implementation plan are publicly available. Finally, an important aspect to be fully developed is the international outreach. This issue needs to be addressed by EU-OPENSCREEN in order to increase the visibility of the Research Infrastructure.

Major Bottlenecks and Possible Measures Which Might impact Further Development
The ERIC operation of EU-OPENSCREEN is expected to be funded for the initial 5 years, as the host Country is investing over EUR 8M. The need to extend the MS/AC commitment, in case a member drops or does not honour the committed funding, must be addressed. The RI is, at this moment, in discussions with nine candidate Countries as potential new ERIC members/observers. A bottleneck is represented by the business model that was chosen based on the full payment by the users of the costs related to their projects. Although the costs of EU-OPENSCREEN are competitive compared with those offered by commercial organisations, these costs may be too high for the majority of the research groups. This bottleneck needs to be carefully evaluated and solutions sought to minimise the risk to the intensive usage and long-term sustainability of EU-OPENSCREEN.
Recommendations
• Continue the discussions with candidate countries to join the ERIC • Develop concrete activities to collaborate with industry on a long-term basis • As a way to create clear value for users, consider using part of the operational budget to cover access fees for users. Build on the model applied by, for example, by Instruct-ERIC.

EU-SOLARIS

ENERGY	
EU SOLARIS	**EU-SOLARIS** **European Solar Research Infrastructure for Concentrated Solar Power**

The European Solar Research Infrastructure for concentrated solar power (EU-SOLARIS) is a distributed Research Infrastructure that aims to achieve a coordination of Research and Technology Development (RTD) capabilities and efforts in Concentrating Solar Power / Solar Thermal energy (CSP/STE) technologies by the European Research centres. EU-SOLARIS aims to become the reference RI for CSP/STE and to maintain Europe at the forefront of these technologies by providing the most complete, high quality scientific portfolio and facilitating the access of researchers to highly specialised facilities via a single access point. EU-SOLARIS will link scientific communities and industry and speed up the development of research and innovation due to a closer collaboration model, knowledge exchange management and a wider dissemination of results.

Typology RI	Distributed
Lead Country	ES
Members	
***Observer (ERIC)**	
Prospective Members	CY, DE, EL, ES, FR, PT, TR
ESFRI Roadmap Entry	2010
ESFRI Landmark	

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EU-SOLARIS	2012-2016	4.4	5.9	
	SFERA III	2019-2022	9.1	9.1	
	TOT	2012-2022	13.5	15.0	1.0
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				6.0
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	TOT				
Legal Status	Pending				
In Operation since	Foreseen 2020 (Currently in transition from Preparation Phase to Implementation Phase, ESFRI Project)				

Implementation Readiness Level and Future Outlook

EU-SOLARIS entered the ESFRI roadmap in 2010 and is currently in a critical phase between preparation and implementation. Detailed plans for the implementation of the RI have been set up in the Preparatory Phase project, and the STEP 1 application for ERIC legal structure has been submitted. However, the process towards implementation seems to be slow. EU-SOLARIS is assessed as being at **RL3**. Progress to RL4 will require the establishment of the ERIC or other legal structure, adequate financial commitments from members, progress in the delivery of services to users and making the Central HUB effective.

Long-term Sustainability

The main goal of the Preparatory Phase was to provide the necessary information for the partners to decide if they plan to participate in the EU-SOLARIS legal entity. This included determining that the best legal structure for EU-SOLARIS is the ERIC, identifying the portfolio of services it should provide to the **industry** and research community, and developing a preliminary business model. Such plants require large investments in engineering and construction, and the timeframe for the returns on such investments is long. Another challenge is bringing national Research Infrastructures, academia and industry together into an open-access Research Infrastructure. The organisational structure and the procedure for regulating access, including a single entry point for users, a **data** management plan, and data production and sharing, must be decided and approved by all partners. KPIs have so far not been agreed on, but a preliminary list of **KPIs** is presented. The current EU-SOLARIS constellation appears to think and operate more as a network than as an integrated unit. It appears that the Preparatory Phase did not proceed as originally expected, presumably partly because the decreased cost of photovoltaic energy has had significant impact on the general situation. Final commitments from partners did not materialise yet. Many members of EU-SOLARIS consortium are partners in SFERA III project. This project aims to further develop and integrate activities between the partners, in particular to develop and detail user access, IPR and data policies. But it is unclear why the members of the future EU SOLARIS ERIC and the SFERA III project are not the same. The infrastructure progress to implementation has suffered from important delays. EU SOLARIS has nevertheless undergone a reorganization and refocussing, that led to the submission of STEP 1.

Major Bottlenecks and Possible Measures Which Might impact Further Development
Since the preparatory project has ended and there is no EU-SOLARIS organisation in place yet, it is currently unclear where the responsibility for pushing the process forward can be found. A business plan was prepared as one of the final actions of the Preparatory Phase. It is stated that this document was delayed because complex issues needed to be resolved and because the focus of EU-SOLARIS has shifted somewhat during the Preparation Phase. The business plan contains three scenarios. The feasibility of the different scenarios and the transformation of the business plan into firm financial commitments are still being discussed. No formal commitment for funding of the implementation has been obtained so far. No cost book and no detailed accounting principles have been set up. Identifying the potential of concentrated solar power and its peculiar role in the energy supply mix should make EU-SOLARIS less vulnerable with respect to energy market oscillations.
Recommendations • Approve by all EU SOLARIS partners a validated projection of operating costs for at least five years and how to cover them. The costs for decommissioning must be identified • Consolidate financial engagements for implementation and operation funding • Establish clear publicly available rules concerning access to research facilities for users including the ones from other EU member states and associated countries • Apply FAIR principles to research data provided by the infrastructure • Undertake activities to expand the innovation potential of the infrastructure • Set up measures to estimate and to enhance the socio-economic impact of the Research Infrastructure • Coordinate activities with other European and international initiatives outside the perimeter of EU-SOLARIS

EURO-ARGO ERIC

ENVIRONMENT

EURO-ARGO ERIC

European contribution to the International ARGO Programme

Euro-ARGO organises and federates the EU contribution to the international ARGO programme for in-situ ocean observations. Euro-ARGO provides, deploys and operates nearly a quarter of the Argo floats deployed in all oceans with more activity in the Atlantic Ocean and the European seas. Euro-Argo provides quality-controlled data and access to data sets and data products to support climate and oceanography research as well as operational oceanography and in particular the Copernicus Marine Service.

Typology RI	Distributed
Lead Country	FR
Members	BG, DE, EL, ES, FI, FR, IE, IT, NL, NO, UK
***Observer (ERIC)**	PL
Prospective Members	PT
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EURO-ARGO	2008-2011	2.9	4.2	
	SIDERI	2011-2013	0.9	1.2	
	TOT	2008-2013	3.8	5.4	NA
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	MOCCA EASME/ EMFF/2015/1.2.1.1	2015-2020	4.0	5.0	
	Euro-Argo RISE	2019-2022	4.0	4.0	
	TOT	2015-2022	8.0	9.0	NA

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ENVRI	2011-2014	3.7	5.1
	AtlantOS	2015-2019	20.7	20.7
	ENVRI PLUS	2015-2019	14.7	15.0
	ENVRI-FAIR	2019-2022	19.0	19.0
	ERIC FORUM	2019-2022	1.5	1.5
	EuroSea	2019-2023	12.7	12.7
	TOT	2011-2023	72.3	74
Legal Status	ERIC, since 2014			
In Operation since	ERIC, since 2014			

Implementation Readiness Level and Future Outlook

Euro-ARGO has been on the ESFRI Roadmap since 2006 and achieved Landmark status in 2016. Euro-ARGO achieved ERIC status in 2014 with nine members. It has subsequently increased membership to twelve. Euro-ARGO has been operational since 2014 and has been developing its long term strategy during this time to enhance and strengthen its data system to serve both the operational and research communities and to develop new services for Members such as joint float procurement, at-sea monitoring of the European fleet and training. Euro-ARGO is considered to be a flagship project in the environmental research domain. Euro-ARGO is assessed as being at **RL5**. Progress toward RL6 implies further integration with other environmental observatory RIs.

Long-term Sustainability

Euro-ARGO has been successful in increasing membership since it reached the ERIC status in 2014. The central ERIC income in 2018 reached EUR 340K which exceeded the planned income by EUR 50K as Bulgaria became a full member and Norway moved from Observer status to full member. Euro-ARGO has bid successfully for several current EC research projects to extend research areas. Several of these are due to end in 2019/2020 (AtlantOS H2020, MOCCA, ENVRIplus). Euro-ARGO has just started a new EC project (Euro-Argo RISE) with the aim of improving the current network as well as extending ARGO observations towards bio-geochemistry, greater depth, partially ice-covered and shallower water regions within a long-term sustainability plan supported by Member States and funding agencies. Through its involvement with the ENVRI-FAIR and BG7 EC projects, Euro-Argo has a leading role in coordinating the Marine Domain and fostering links with other environmental RIs in terms of data FAIRness, enhanced services to users and contributing to the European Ocean Observing System. The **scientific excellence** of the RI can be seen through the high number of papers published since it reached ERIC status; the number of published papers dipped to 82 in 2018 (down from 113 in 2017 and the peak of 125 registered in 2016) but went up to 112 in 2019. A similar dip was seen at Argo international level and a possible explanation is that scientists use ARGO products without giving appropriate citation. Completing its first five years of operation in 2018, Euro-ARGO has recently defined the plans for the next 5-year period through an evaluation process between the Scientific and Technical Advisory Board and the Council. The 5-year report and 5-year plan are both available on Euro-Argo web site. Euro-ARGO provides the **data management** component of the international ARGO data system and guarantees that data from all floats deployed by the European partner is processed in real time and delayed mode according to the Argo recommendations. In December 2019, more than 400,000 data profiles from 3800 European floats were available on the ARGO GDAC representing 23% of the global network. Euro-ARGO aims to provide up to date reference materials for a broad range of audiences including the general public, scientists, educators, and manufacturers. The website provides access to national reports from member countries which show how the RI has been used which helps to demonstrate its **socio-economic impact**. In its 5-year report, Euro-ARGO states that it measures its performance against **KPIs** related to the floats and KPIs related to RI users. In terms of **innovation**, Euro-ARGO's partnership with a European float manufacturer has been instrumental in increasing their share of the global float market. In 2018, Euro-ARGO began an **industry** partnership with telecommunications company Orange Marine which has supported the deployment of additional floats in remote areas of the South Pacific helping Euro-ARGO to increase its contribution to global effort in a cost effective way.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Euro-ARGO has been successful in increasing its membership since it became an ERIC and the importance of ARGO for European operational services such as Copernicus Marine (CMEMS), Climate (C3S) and EMODnet is clear. Euro-ARGO has also been very successful in securing project funding and is currently entering a new cornerstone of its development with the implementation of a new design that is currently being developed through national and EC projects. The new design costs three times that of the initial design and implementing it will require new and sustained funding streams to be identified. While funding for Euro-ARGO's core mission appears stable, there is a risk that implementing Euro-ARGO's new design becomes dependent upon EU project funding and diversification of funding sources should be prioritised - particularly to ensure continued global coverage. In fact funding should come both from national and EU sources as all services (including European ones like Copernicus and EMODnet) rely on Euro-ARGO data for the quality of their products.

Recommendations

- Efforts should be made to identify alternative sources of funding to support the implementation and sustainability of the new Euro-ARGO design
- Euro-ARGO should provide greater clarity on how to cite the RI to ensure that proper reference to its contribution to research is made, consolidating the recently recovered positive trend in publications.
- As a partner in the ERIC Forum, efforts should be made to develop shared strategies to identify alternative funding streams.
- Euro-ARGO should investigate potential avenues for increasing partnerships with industry.

Euro-BioImaging ERIC

HEALTH & FOOD	
	Euro-BioImaging ERIC **European Research Infrastructure for Imaging Technologies in Biological and Biomedical Sciences**
Euro-BioImaging is a distributed Research Infrastructure that provides open access to state-of-the-art biological and biomedical imaging technologies for researchers. Euro-BioImaging provides advanced image, data, and training services for performing cutting-edge research in the life sciences using imaging technologies.	

Typology RI	Distributed				
Lead Country	Statutory Seat: FI, country hosting Euro-BioImaging ERIC, 'Bio-Hub': Part of the Euro-BioImaging Hub hosted by EMBL; 'Med-Hub': Part of the Euro-BioImaging Hub hosted by Italy				
Members	AT, BG, CZ, DK, FR, IL, HU, IT, NL, NO, PT, SE, SI, UK, EMBL				
***Observer (ERIC)**	BE				
Prospective Members					
ESFRI Roadmap Entry	2008				
ESFRI Landmark	2018				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	EURO-BIOIMAGING	2010-2013	5.2	6.9	
	Euro-BioImaging PPII	2016-2018	1.5	1.5	
	TOT	2010-2018	6.7	8.4	5.2

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				21.0
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	Global BioImaging	2015-2018	1.7	1.7	
	iNEXT	2015-2019	10.0	10.0	
	RITRAIN	2015-2019	2.0	2.0	
	CORBEL	2015-2020	14.8	14.8	
	ERIC Forum	2019-2023	1.5	1.5	
	EOSC-Life	2019-2023	23.7	23.7	
	TOT	2012-2023	64.2	67.4	
Legal Status	ERIC, since 2019				
In Operation since	2016				

Implementation Readiness Level and Future Outlook

Euro-BioImaging has been on the ESFRI Roadmap since 2008 and completed its second Preparatory Phase project in 2018. Euro-BioImaging achieved ERIC status on 29th October, 2019. Euro-BioImaging has been conducting limited interim operations between May 2016 and November 2019, and ramped-up operations started on 17 December 2019. Euro-BioImaging is assessed as as being at **RL5**. Progression to RL6 depends largely on securing additional funds to enable the RI to realise full operation and to bring on new services as required.

Long-term Sustainability

Euro-BioImaging statues indicate that an annual review of the activities will be carried out by the Euro-BioImaging Scientific Advisory Board to ensure **scientific excellence**. To stay at the technical forefront and to foster **innovation**, Euro-BioImaging has developed a workflow to identify new technologies that should be adopted by the RI and established an Industry Board to foster cross collaboration between academia and industry. The costs and benefits of industry membership are clearly presented on the dedicated Euro-BioImaging Industry Board website and associated flyer. The Euro-BioImaging Industry Board collaborates closely with Euro-BioImaging partners and has recently participated in meetings to discuss training opportunities at the interface of Nodes' staff, new imaging technologies, image data analysis tools, and industry. Euro-BioImaging is currently defining a quality management plan, which will ensure that performance can be measured against **KPIs**. Euro-BioImaging encourages open access to research data generated through its services and provides advice to users on completing data management plans. Each of the three key data services (BioImage Archive, Image Data Resource, and Image Tool Resource) provide data submission guidance to end users and there is a Euro-BioImaging **data policy** available from the main website. Euro-BioImaging offers three levels of **training** (general, specific and advanced) which are targeted to current and future users of the RI including masters and PhD students, post-graduates, senior scientists, technicians as well as staff of imaging facilities. Euro-BioImaging participates in **internationalisation** through the EC supported Global BioImaging network of imaging infrastructures and communities. Euro-BioImaging is active in **clustering** activities including CORBEL and EOSC Life and has recently signed bilateral collaboration agreements with several related RIs including Instruct ERIC, Elixir, and EU-OPENSCREEN ERIC.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Euro-BioImaging has sixteen members, and in addition, Poland and Spain have communicated their strong commitment in the form of Letters of Intent to join the Euro-BioImaging ERIC as soon as the national procedures are completed. The total budget provided by current members is almost three times higher as it was during the Preparatory Phase PPII (EUR 0.5 million/year) and currently covers 89% of basic operations (EUR 1.54 million/year). Euro-BioImaging states that from January 2020 onwards it can bring up its operations to at least 92% and soon to the full potential with the budget currently secured by the membership contributions. As Spain and Poland join, it is expected that 100% of operations should be realised by the end of 2020. Since the approval of the financial plan in December 2019, the budget for Euro-BioImaging operation is in place for 5 years, serving up to 500 individual users for access to the Nodes. Indeed, there appears to be strong interest in Euro-BioImaging and good feedback from users so far. However, the RI acknowledges that it needs to bring on new members within the first five years to support new, additional services to be added - based on user requests - beyond the approved basic operations. Euro-BioImaging will seek additional funding to support outreach activities, but given the importance of increasing membership, the strategic planning should ensure that sufficient resources are allocated to marketing efforts from the funds currently available. As noted in a previous assessment, Euro-BioImaging needs to recruit senior level staff including a Directorate (composed of a Director General and two section Directors for the Bio-Hub and the Med-Hub). International open advertisement of these three positions is planned to happen in the first months of 2020 following launch of the ERIC. To ensure smooth operation of the infrastructure, at the first Euro-BioImaging ERIC Board meeting in December 2019, an Interim Directorate has been appointed. The major governance bodies, the Euro-BioImaging Board, the Scientific Advisory Board (SAB), the Panel of Nodes, and the Advisory Panel of the Euro-BioImaging Industry Board are also to be established directly after the first Board meeting. As ERIC status was only achieved at the end of October 2019, it is expected that recruitment of the Directorate will be completed in the course of 2020. Euro-BioImaging have noted that securing sustainable and sufficient TA funding is also a major challenge.

Recommendations

- While there is an interim Directorate in place, recruitment of the and population of the governing bodies should be a key priority for Euro-BioImaging in the short-term.

- Membership is currently strong and will cover almost all of the operational costs for the first five years. If Spain and Poland join as planned, the costs will be fully covered. However, to ensure new services can be brought in to meet user requests, securing additional membership should be prioritised.

- Euro-BioImaging should identify alternate income streams such as value-added service provision and consultancy to help ensure that full operations can be realised in the event that the planned additional membership cannot be secured.

IAGOS

ENVIRONMENT	
	IAGOS **In-service Aircraft for a Global Observing System**
IAGOS is a global observing system for long-term observations of atmospheric composition using high-tech instrumentation deployed aboard In-service commercial aircraft. IAGOS combines the expertise of scientific institutions with the infrastructure of civil aviation in order to provide essential data on climate change and air quality at a global scale.	

Typology RI	Distributed				
Lead Country	DE, FR				
Members	DE, FR, UK				
***Observer (ERIC)**					
Prospective Members					
ESFRI Roadmap Entry	2006				
ESFRI Landmark	2016				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	IAGOS Design (FP6-INFRA)	2005-2010	2.8	4.5	
	IAGOS-ERI	2008-2013	3.3	4.4	
	TOT	2005-2013	6.1	8.9	3.5

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	IGAS (FP7-SPACE)	2013-2016	2.0	2.6	
	TOT	2013-2016	2.0	2.6	45
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ENVRI	2011-2014	3.7	5.1	
	ENVRI PLUS	2015-2019	14.7	15.0	
	ENVRI-FAIR	2019-2022	19.0	19.0	
	TOT	2011-2022	37.4	39.1	
Legal Status	AISBL, since 2014				
In Operation since	2014				

Implementation Readiness Level and Future Outlook

IAGOS is an ESFRI Landmark and has been on the roadmap since 2006. Incorporated as an AISBL, it is operational and is providing data to users and open data access under basic FAIR principles. Accordingly, it is assessed as being at **RL5**. IAGOS currently has 8 aircraft equipped with fully operational instrumentation. This falls short of the 20 originally envisaged and hoped for. In this respect IAGOS is focussed both on ensuring long-term sustainability of the existing infrastructure while working to increase the number of operating, instrumented aircraft.

Long-term Sustainability

The main threat to **financial sustainability** relates the need for long-term funding commitments from funding agencies and the airline and aerospace sectors. In addition to strengthening existing partnerships, there needs to be a sustained effort to secure funding from additional partners both from funding agencies and industry. In this regard, a lack of human resources is limiting the international outreach that would be essential to secure support from new partners. In terms of **scientific excellence**, IAGOS operates an access policy that ensures open access to data regardless of origin. The publication rate for IAGOS is currently in the region of 20 per year. Nevertheless, the size of the active user community compared with the potential user community is not clear. IAGOS states that their data are used by over 550 scientific groups, but it is unclear how active these groups are given the number of publications. A survey of user demand would help to direct user engagement and outreach to increase the use of the data, **exploit better the data generated by IAGOS** and help to justify future investment. Lack of human resources is cited as a limitation in this area. Regarding the **attraction and training of the managers, operators and users of tomorrow**, the reliance of IAGOS on short-term funding means that they need to attract and train short-term younger staff on 1-2 year contracts which makes development and retention of experienced staff problematic. The participation institutes in IAGOS are involved in Master and PhD training, but there is not much information on the website regarding training and support for new users. This could be an impediment to growing the user community. Activities relating to **innovation potential** are focused on instrumentation where there is clear benefit to those industries involved. There is little information available regarding industrial or commercial use of data or what the policy on this is, though the current statutes may limit this. It is not clear therefore what potential exists for commercial exploitation (and possible income) of the data. **Socio-economic impact** relating to climate and climate change studies in general is clearly high. IAGOS should develop case studies that specifically demonstrate the contribution that IAGOS has and can make, to help make the case for new funding.

Major Bottlenecks and Possible Measures Which Might impact Further Development

It is clear that funding and particularly long-term funding remains a bottleneck with the hoped-for new partner Countries apparently not signing up as yet. The funding that is available from the German, French and UK partners is long-term, however, it does not fully cover the continuous development of the infrastructure, which restricts long-term planning and staff planning. Evolving certification requirements and the difficulty of finding airlines partners have been additional significant bottlenecks in achieving the goal of 20 operational aircraft. This, in part at least, is also a financial issue in that the development of lighter and more autonomous instrumentation would help in the search for partner airlines or persuade airlines to equip further aircraft from their fleets. While EU funding has clearly been critical to the successful establishment of the IAGOS, it is not clear that it will be sustainable in the future without continued EU support unless other funding and new partners can be secured.

Recommendations

- Carry out an assessment of the current and future potential users (research and commercial) and identify target groups for increased outreach. It will be important to demonstrate that there is a user community, otherwise IAGOS will look more like a research project than a European RI.
- Develop training strategies and plans for new user training and support.
- Explore the potential and any limitations in the AISBL statutes for industrial/commercial use of data and develop appropriate access policies. As a potential source of revenue, consider and investigate option for commercialisation of (parts of) the technology behind IAGOS.
- Develop case studies to demonstrate specific IAGOS contributions to studies of climate and climate change.
- Work with existing funders to develop plans to attract new users and additional partners.
- Estimate the cost of designing a new generation of instruments that could considerably reduce the weight and cost of systems, which may increase the number of carriers available to the project.

ICOS ERIC

ENVIRONMENT

ICOS ERIC

ICOS
Integrated Carbon Observation System

The Integrated Carbon Observation System (ICOS) is a distributed Research Infrastructure to generate high-precision data and integrate knowledge on the carbon cycle and greenhouse gas (GHG) budgets and of their perturbations. ICOS conducts long-term observations in three networks – atmosphere, ecosystems, and oceans – as required to understand the present state and extrapolate to the future behaviour of the global carbon cycle and GHG fluxes. ICOS has an increasing role in scientific support of climate policy. The most important technological impact is standardisation. Further technology developments and implementation, related to GHGs, will be promoted by a close integration of research, education and innovation.

Typology RI	Distributed
Lead Country	FI
Members	BE, CZ, DE, DK, FI, FR, IT, NL, NO, SE, UK
***Observer (ERIC)**	CH
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ICOS	2008-2013	4.3	5.7	
	TOT	2008-2013	4.3	5.7	4.3
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	RINGO	2017-2020	4.7	4.7	
	TOT	2017-2020	4.7	4.7	80

Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ENVRI	2011-2014	3.7	5.1
	INGOS	2011-2015	8.0	10.4
	COOPEUS	2012-2015	2.0	2.3
	ICOS-INWIRE	2013-2015	2.0	2.6
	ENVRI PLUS	2015-2019	14.7	15.0
	RITRAIN	2015-2020	2.0	2.0
	EOSCpilot	2017-2019	10.0	10.0
	RISCAPE	2017-2019	2.0	2.0
	RI-VIS	2019-2021	1.5	1.5
	ENVRI-FAIR	2019-2022	19.0	19.0
	ERIC FORUM	2019-2022	1.5	1.5
	TOT	2011-2022	66.4	71.4
Legal Status	ERIC, since 2015			
In Operation since	2016			

Implementation Readiness Level and Future Outlook

ICOS entered the ESFRI roadmap in 2006. It is finalising its implementation phase, becoming operational with the first data of labelled stations becoming available. ICOS achieved the ERIC status in November 2015 and the Landmark status at the ESFRI Roadmap in 2016. ICOS has reached operational stage and has a high potential to become a reference pan-European facility. It is currently assessed as being at **RL5**, and it will further progress towards RL6 within cluster projects.

Long-term Sustainability

User categories have been defined by the outreach committee and their needs characterised from a survey. The ICOS User Needs Report contains key element for shaping the ICOS outputs around the users' needs and allowing potential users to efficiently exploit the ICOS products. The **KPIs** will be designed to monitor and evaluate the success of all the ICOS RI management sectors: data dissemination and scientific impact, user liaison and other external relationships, core RI operations, resources, personnel. ICOS is organising internal **training** events for scientists and technicians; it also participated in several summer schools to train early-career scientists to use ICOS data. For dissemination toward pupils and students ICOS-PP has collaborated with the FP7 EU project CarboSchools+ (that linked researchers from several leading carbon science laboratories in Europe with secondary schools around pedagogical projects) and with the climate-KIC (Knowledge and Innovation Community). The most important **innovation** of ICOS is the development of harmonised and standardised methodologies concerning open data. Elaborated products bridge between science and society and enable societal innovation related to climate change mitigation. A common **data** centre, the Carbon Portal, provides free access to ICOS data services, links to fossil fuel emission inventory data, and outreach material towards science and policy communities, and to the general public. The access to ICOS data is open and free. All ICOS data are distributed using international license through the ICOS carbon portal and the ICOS one-stop shop. Distributed data processing structure, the calibration lab takes care of the central provision of calibration standards and analysis of flask samples. ICOS cooperates **internationally** to provide comprehensive information on the Earth's climate system. Its activities are the European contribution to the Global Climate Observation System. It provides vital and continuous support to the United Nations Framework convention on climate change, participates in the group on Earth observation, and actively supports the initiative on carbon and greenhouse gases and the global greenhouse gas information system developed by the world meteorological organisation. In the coming year the Copernicus Programme will initiate the dialogue with Research Infrastructures such as ICOS to ensure systematic access to in situ observations in an operational context.

It terms of **impact,** ICOS also has a unifying effect on the governmental levels by means of science diplomacy. An international collaboration like ICOS brings together not only scientists but also representatives of environment-related ministries. The fact that there is a high level of rigor and organization in the production of data sends a clear message to stakeholders that there is a broader vision than one project or even national strategy.

The EC RI support measures and the ESFRI process have supported the essential infrastructure's structuring issues and have been the necessary instruments in triggering the maturity and implementation of ICOS.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The long-term sustainability of ICOS as a distributed Research Infrastructure, depends to a large extent on the national engagement and the responsibilities of the member states. In order to minimise the risk in future funding of the essential observation networks, ICOS needs to further consolidate this distributed Research Infrastructure. It should try to find, develop and implement unique ICOS data products, not only relying on distributing high quality observations and an open excellent data flow to other synthesising projects, as, for example, the Global Carbon Project. ICOS should aim on establishing unique ICOS data products and communicate them directly as results of ICOS. Future researchers and decision-makers will need actual observed emissions for different regions. Through interaction with stakeholders on the policy side, ICOS should develop new metrics directly based on the observation that can be used directly in international negotiations.

Coordinating the development of the in-situ observations and later implementing them with Copernicus Programme goes beyond the classical model of a Research Infrastructure since this activity will combine research with more agency-like monitoring. This is a complex undertaking because of the financial and administrative implications, and it requires thorough planning.

Recommendations

- Pursue robust national engagement of members.
- Better coordinate the national nodes' funding to optimising ICOS as a pan-European RI.
- Develop and implement a catalogue of unique ICOS data products and promote these
- Develop new observation-based metrics as a tool for international negotiations
- Look for support of the member states in the upcoming dialogue with Copernicus Programme
- Foster FAIR data and compliance with the EOSC

INFRAFRONTIER

HEALTH & FOOD

INFRAFRONTIER

Generation, Phenotyping, Archiving and Distribution of Mouse Disease Models

INFRAFRONTIER is the European Research Infrastructure providing the biomedical research community with the tools needed to study the systemic effects of genetic alterations to unravel the role of gene function in human health and disease. It offers access to a unique collection of mouse models and research tools and associated data, and to state of the art technologies for mouse model development and phenotype analyses. INFRAFRONTIER enhances medical research by promoting studies that lead to breakthrough discoveries in cancer, metabolic and cardiovascular diseases, infectious diseases and the group of rare diseases. INFRAFRONTIER partners form the European component of the global Research Infrastructure IMPC (International Mouse Phenotyping Consortium).

Typology RI	Distributed
Lead Country	DE
Members	CZ, DE, EL, FI, FR, SE
***Observer (ERIC)**	
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	INFRAFRONTIER PP	2008-2012	4.5	6.1	
	INFRACOMP	2011-2014	0.8	1.0	
	INFRAFRONTIER I3	2013-2016	9.9	12.4	
	TOT	2008-2016	15.2	19.5	NA
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	IPAD-MD	2015-2019	1.1	1.1	
	INFRAFRONTIER 2020	2017-2020	5.0	5.0	
	TOT	2015-2020	6.1	6.1	NA
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	RITRAIN	2015-2019	2.0	2.0	
	CORBEL	2015-2020	14.8	14.8	
	RI-VIS	2019-2021	1.5	1.5	
	ERIC Forum	2019-2022	1.5	1.5	
	EOSC-Life	2019-2023	23.7	23.7	
	TOT	2012-2023	54.0	57.2	

Legal Status	GmbH, 2013
In Operation since	2013

Implementation Readiness Level and Future Outlook
INFRAFRONTIER is an ESFRI Landmark and has been on the ESFRI roadmap since 2006. Its current legal status is GmbH, the infrastructure is operational and is providing services, data to users and open data access consistent with the FAIR principles. It is part of the global IMPC aiming to reach the complete mouse genome encyclopaedia. Accordingly, INFRAFRONTIER is assessed as being at **RL5**. INFRAFRONTIER is on the way to RL6 and is actively participating in cluster projects which bring together the Research Infrastructures in the field of biology and health, aiming to bring the capabilities of big science projects to the wider research community.

Long-term Sustainability

Provision of **access** to mouse production and 1st line phenotyping services and free of charge access to a unique and specialized service to derive, maintain and distribute germ-free mice, have been put in place by INFRAFRONTIER that is based on the activity of mostly national investments in mouse-clinics. The European Mouse Mutant Archive (EMMA), which is operated by INFRAFRONTIER, is the largest mutant mouse repository in Europe and the third-largest world-wide, distributing mouse strains globally. The **excellent science** is realised as direct research and supply of samples to the academic and industrial research. The **impact** and **socio-economic** effects of the ultimate goal of INFRAFRONTIER and IMPC (**internationalization**) can be enormous in accelerating research on human diseases through the completion of the mouse model. This goal is challenged by other animal models or in-silico models and therefore a clear timeline of delivery of the science programme must be updated with a strategic view. Highly standardized (globally) production of mutant mice and data collection/validation/curation is a key ingredient for the exploitation of the emerging mouse mutant resources, , linking basic biomedical research to medical applications and thereby driving **innovation**. The INFRAFRONTIER Research Infrastructure and its partners offer a wide range of state-of-the-art training opportunities and consulting services: The EMMA nodes and mouse clinics in different European countries provide outstanding training in cryo-preservation methodology, first-line mouse phenotyping as well as specialised phenotyping courses covering e.g. mouse osteology and mouse blood and lymphatic vessel phenotyping. In the frame of the second Preparatory Phase grant, provision of user-friendly access to all INFRAFRONTIER resources and services via a new portal were adopted, as well as extensive manual data curation underpinning **data quality**, and cross referencing and integration with other mouse resources. The INFRAFRONTIER bibliography and INFRAFRONTIER's rare disease related pages also integrate data from external resources. The INFRAFRONTIER database reengineering was initiated after a workshop in March 2017, where detailed requirements from experienced users of the INFRAFRONTIER network were compiled providing a solid foundation for the development of a new schema for the central INFRAFRONTIER database. In order to jointly present resources and services INFRAFRONTIER can offer to industry, a liaison workshop was organised as a major deliverable of the second Preparatory Phase grant. Effort to **liaise with industry** was jointly undertaken with the International Mouse Phenotyping Consortium (IMPC). The post Preparatory Phase grants address cooperation and coordination between the pan-European INFRAFRONTIER Research Infrastructure and complementary **international** Research Infrastructures in America, Asia and Australia.

To improve the overall operational performance and to provide a basis for sustainable development initiatives, INFRAFRONTIER2020 aims to adopt a **quality management** (QM) system for the INFRAFRONTIER legal entity. As a first step a broad context analysis was carried out and a detailed process map of the INFRAFRONTIER legal entity was developed. A formal application to obtain ERIC status was submitted to the EC in summer 2016. The expanded INFRAFRONTIER2020 network (an on-going post Preparatory Phase grant) includes 3 SMEs and has an objective to advance the long-term sustainability by 1) development of business models and a stable legal framework; 2) raising awareness of the INFRAFRONTIER RI; 3) providing services aligned with user demands; 4) promoting best practices in mouse phenogenomics; 5) enhancing robustness of the INFRAFRONTIER IT infrastructure and 6) improve business processes. The advantages of the adoption of ERIC status instead of the current GmbH has been carefully assessed.
Major Bottlenecks and Possible Measures Which Might impact Further Development The primary goal of INFRAFRONTIER is to provide access to gold-standard resources, technologies and services to a global user community and to propagate reliable research outcomes in animal experimentation and the application of the 3Rs (Replacement, Reduction, Refinement). INFRAFRONTIER also contributes crucially to the completion of the IMPC project of Mouse genome phenotyping. This has a fundamental time element that can be tackled by maximizing the number of laboratories contributing to the research so to proceed in parallel. A robust IT infrastructure is also a critical element to integrate operational activities in INFRAFRONTIER, and further support the interfacing with the user community and thus the sustainability of the INFRAFRONTIER infrastructure. Innovation of animal research tools and methods is an asset. The benefits to the European pharmaceutical industry must be exploited to the maximum extent but avoiding prevalence of industrial interests. The establishment of the adequate framework conditions for a sustainable long-term funding is still an issue for INFRAFRONTIER. Even if a transitional GmbH legal status is a reliable solution, the ERIC status mentioned already in the first Preparatory Phase would provide INFRAFRONTIER with the real robust and sustainable framework, but it does not seem to proceed swiftly to the phase 2. A robust IT infrastructure is the most critical element to integrate operational activities in INFRAFRONTIER and further support the interfacing with the user community and thus the sustainability of the INFRAFRONTIER infrastructure.

Recommendations

- Federate all national laboratories in Europe that collaborate with IMPC.
- Make INFRAFRONTIER RI the European Representation in IMPC. All European facilities in IMPC should be formal members of INFRAFRONTIER RI in order to bring coherence and transparency to the procedures of the European partners.
- Support the national engagement in mouse clinics and their full compliance with INFRAFRONTIER standards, showing (also quantitatively) the benefits of accelerated and integrated research in the domain.
- Strengthen the legacy with IMPC to accelerate the establishment of the Global Research Infrastructure and explain what value added INFRAFRONTIER is bringing to its members.
- Make the long-term science programme clear, i.e. the next goals after first level phenotyping of mouse mutants.
- Promote integration in the Health and Food domain and bio-data bases/ bioinformatics.

INSTRUCT ERIC

HEALTH & FOOD	
	INSTRUCT ERIC **Integrated Structural Biology Infrastructure**

Instruct-ERIC provides researchers with access to state-of-the-art structural biology technologies and expertise. Equipment at the cutting-edge of structural biology is increasingly expensive to build and maintain and no European country possesses such equipment and expertise in all structural biology technologies. Instruct-ERIC enables its members to access this equipment and expertise through a dynamic, sustainable, infrastructure distributed across Europe.

Typology RI	Distributed				
Lead Country	UK				
Members	BE, CZ, DK, ES, FI, FR, IL, IT, LV, NL, PT, SK, UK, (EMBL)				
***Observer (ERIC)**	EL				
Prospective Members					
ESFRI Roadmap Entry	2006				
ESFRI Landmark	2016				
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	INSTRUCT	2008-2011	4.5	7.5	
	TOT	2008-2011	4.5	7.5	8

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	INSTRUCT-ULTRA	2017-2020	4.0	4.0	
	TOT	2017-2020	4.0	4.0	175
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	iNEXT	2015-2019	10.0	10.0	
	CORBEL	2015-2020	14.8	14.8	
	OPEN SESAME	2017-2019	2.0	2.1	
	RI-VIS	2019-2021	1.5	1.5	
	ERIC Forum	2019-2022	1.5	1.5	
	EOSC-Life	2019-2023	23.7	23.7	
	iNEXT-Discovery	2020-2024	10.0	10.0	
	TOT	2012-2024	74.0	77.3	
Legal Status	ERIC, 2017				
In Operation since	2017				

Implementation Readiness Level and Future Outlook Instruct has been on the ESFRI roadmap since 2006 and is an ESRI Landmark. Incorporated as an ERIC in 2017, it is operational and has been providing open access to high-end structural biology services and techniques since 2012. Services are provided by Instruct Centres located in member Countries with access costs provided from membership contributions to the Instruct-ERIC. Instruct is assessed as being at **RL5**. Instruct-ERIC is a partner in Corbel and EOSC-Life and is moving towards RL6.
Long-term Sustainability Instruct addresses or is addressing all of the preconditions for sustainability, the mid-term review of the Instruct-ULTRA project recommended however that 'efforts are made to engage the infrastructure users, and make sure that all the relevant stakeholders continue to have an effective input into decision making'. The report also noted that: 'Although there are plans for communicating with the media, the plans for communication directly with the general public are not clear enough'. Regarding **scientific excellence**, Instruct-ERIC carries out peer review on all applications for access to services and techniques. Additionally Instruct-ERIC has scheduled comprehensive scientific reviews of all of its Centres ahead of a new funding cycle to ensure that standards remain high and that the services offered meet the demands of users. In order to maintain scientific excellence, it is important that Instruct continues efforts to remain connected to users and other stakeholders. User forums and outreach activities are important in this respect. As funding for the facilities and services offered by Instruct are reliant on investments by member Countries hosting Instruct-Centres, building support from the communities in those countries is particularly important. Instruct is very active in attracting and **training managers, operators and users of tomorrow**. For example; Instruct trains its users through specific courses and workshops in how to use Instruct services and funds practical training courses on-site at facilities to train operators in new methods. By its nature Instruct has huge **innovation potential** though demand for access by industry has so far not been high. To address this an industrial liaison programme has been established as part of the Instruct-ULTRA project and the Instruct website has a page dedicated to industrial access. IP is a potential impediment to industrial use and Instruct appears to lack a clear policy on both industrial access and intellectual property. Regarding the **Structuring the international outreach** Instruct is actively engaging with communities in Latin America, South Africa and Australia, South-East Asia and India. These are valuable initiatives but in terms of long-term sustainability, it will be important that Instruct does not become overstretched at the expense of supporting its core activity. The Instruct-ERIC Council is aware of the need to monitor this.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Instruct is fully operational, providing access to a wide and growing range of structural biology facilities. To date this access has been instrumental in 900 publications (175 in 2018). As such it can be considered to be extremely successful from the scientific point of view. Long-term funding is a potential bottleneck both from the point of view of membership contributions to Instruct-ERIC to fund access costs and also in relation to future investment in Instruct-Centres. This is being addressed in part by the Instruct-ULTRA project, which is expanding membership and partnerships within Europe and more widely.

Recommendations

- Continue efforts to engage with users via user forums, meetings and training activities to ensure that Instruct remains responsive to the current and future needs of a growing user community.

- Instruct needs focus particularly on stakeholder engagement in current and potential future hosts of Instruct-Centres to ensure that the wider benefits of local investments are promoted.

- Ensure that the valuable global connections being explored by Instruct are balanced against the need to ensure long-term sustainability of the core activity.

- Continue efforts to attract new members and to establish new Instruct -Centres within Europe and more-widely, driven by user demand and needs.

ISBE

HEALTH & FOOD	
ISBE Infrastructure for Systems Biology Europe	**ISBE** **Infrastructure for Systems Biology Europe**
The Infrastructure for Systems Biology Europe (ISBE) is a distributed Research Infrastructure aimed at enabling efficient access to the best expertise, resources and services, such as model building, fit-for-modelling data, tools and training in systems biology. ISBE is being built through a matrix of interconnected national systems biology centres which will set, improve and promote standardisation of biological data, tools and models as well as operating procedures, ensuring that resources from different laboratories, countries and sectors can be integrated and become re-usable. ISBE has a potential in enhancing the European bioeconomy by providing resources and services to academia, industry and the public sector to deliver solutions that address Grand Challenges in healthcare, food production, quality of life, and sustainable bio-energy.	

Typology RI	Distributed
Lead Country	Pending
Members	
***Observer (ERIC)**	
Prospective Members	IT, SI (11 IN PP)
ESFRI Roadmap Entry	2010
ESFRI Landmark	

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	ISBE	2012-2015	4.7	6.6	
	TOT	2012-2015	4.7	6.6	4.7
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				10
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	CORBEL	2015-2020	14.8	14.8	
	EOSC-Life	2019-2023	23.7	23.7	
	TOT	2012-2023	49.0	52.2	
Legal Status	Pending				
In Operation since	Foreseen 2019				

Implementation Readiness Level and Future Outlook

ISBE entered the ESFRI roadmap in 2010. The Preparatory Phase was concluded in 2015, but no information about its further progress is available on the infrastructure's website. No evidence of achievement of substantial steps in the construction of the RI is available. It is assessed as being at **RL2**.

Long-term Sustainability

The project has been in the interim phase on the way to implementation since the end of the Preparatory Phase in 2015. The coordinating Country, the UK, left in summer 2016 and the coordination was assumed by the Netherlands who coordinated a small portfolio of services managed by each national node. The RI project lost momentum and several national nodes started to merge with ELIXIR national nodes, reducing progressively the initial partnership of ISBE. In summer 2017 the Italian national node proposed a bottom-up initiative “ISBE-to-ERIC” with Italy as interim coordinator with one goal: to push national governments to support the creation of ISBE ERIC, the legal entity selected in the Preparatory Phase. This initiative failed as ISBE hasn’t managed to put in place a Research Infrastructure with clear shared vision and mission. The Preparatory Phase was focused on the computational aspects of systems biology, but this choice split the community, particularly when a larger Research Infrastructure like ELIXIR is becoming a reference as provider of data and tools for bio-informatics and life sciences in general. Most ISBE activities in the field of data management were planned to operate through the structure of FAIRDOM. However, activities outside FAIRDOM were neither fully nor clearly addressed. The plans for data management were not elaborated in depth and the e-services provision remain at a generic stage of description. In terms of data, data security and range of users, it is unclear whether the ad-hoc arrangements and agreements presented build a strong central link with the individual users or if the activities rely entirely on resources offered by ISBE partners. ISBE remains a collaborative network of national systems biology centres, with overlapping and complementary expertise.

Systems biology clearly has potential for developing innovative products and processes in many industrial applications from food to energy. In principle, the services provided by a RI in the field of Systems Biology would be of high impact, e.g. on personalised medicine, the provision of alternative nutrition concepts and sustainable food production. A line of work that it is very appropriate for precision medicine, industrial applications (biofermentation, useful for Green Deal) and food utilisation in health and disease, is systems metabolomics. This area (experimental and computational) may be the focus of forthcoming activities of the National Nodes and in particular of ISBE Italy, which is actively involved in it, has already obtained scientific results, and provides metabolomics services to the scientific community. The deliverables of such RI could boost the bio-based economy through production of new and improved biofuels and bio-based materials. Moreover, waste and water management, protection and conservation of the environment could benefit. Clearly, the above described concepts have been the foundations of the ISBE project. However, ISBE did not consolidate the scope of a centralised and organised structure or a common vision of its actions. ISBE is today a network of scientists and institutions. Collaboration with other Research Infrastructures in the biological and medical sciences will help to optimise coordination, harmonisation, integration and interoperability of systems-biology data and applications.

Major Bottlenecks and Possible Measures Which Might impact Further Development
ISBE has made progress on delivery of services with the spring 2017 launch of ISBE light but the infrastructure and service provision are not consolidated. A robust and sustainable plan for service provision has not been implemented and the various modules /platforms are too loosely connected to represent a RI. The institutional participation in ISBE at the European level has reduced to a subcritical level and no convincing strategy to invert this trend is formulated. A reorientation of effort to a different format of collaboration should be considered in order to preserve and develop the scientific potential and productivity if the relevant community.
Recommendations
• ISBE should reorient its scientific programme into a different format of international collaboration, as the attempt to establish a Research Infrastructure in the ESFRI framework did not lead to progress • The needs and interests of the systems biology scientific community could be assured by collaboration and integration of actions with consolidated pan European initiatives like ELIXIR and CORBEL or with advancing RIs such as EMPHASIS and others. • The size and the type of user community should be better identified and targeted in order to provide it with the needed services and not to make it marginal within bigger initiatives.

JIVE ERIC

PHYSICAL SCIENCES & ENGINEERING

JIVE ERIC

Joint Institute for VLBI ERIC

Very Long Baseline Interferometry (VLBI) is a technique used in radio astronomy, whereby telescopes spread across the Earth coordinate as an array to produce extremely high-resolution images when studying cosmic radio sources. Such results contribute to answering some of the most fundamental questions in astronomy and physics. The successful operation of VLBI requires cross-institutional collaboration and coordination – which currently occurs in Europe through the European VLBI Network (EVN) and the Joint Institute for VLBI European Research Infrastructure Consortium (JIV-ERIC, or JIVE). The EVN is a network of telescopes and institutions across the globe, and JIVE is the central organisation in the EVN. Data from EVN telescopes is processed at JIVE, which also provides network and user support, conducts leading research and fosters technical development in the field of radio astronomy.

Typology RI	Distributed
Lead Country	NL
Members	ES, FR, LV, NL, SE, UK
***Observer (ERIC)**	
Prospective Members	
ESFRI Roadmap Entry	not on the ESFRI Roadmap
ESFRI Landmark	not on the ESFRI Roadmap

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	JUMPING JIVE	2016-2021	3.0	3.3	
	TOT	2016-2021	3.0	3.3	
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	ERIC Forum	2019-2022	1.5	1.5	
	ESCAPE	2019-2022	16.0	16.0	
	TOT	2019-2022	17.5	17.5	
Legal Status	ERIC, since 2015				
In Operation since	2015				

Implementation Readiness Level and Future Outlook

JIVE is a long-established RI that provides the underpinning data processing and user services that enable the individual radio telescopes of the European Very Long Baseline Interferometry Network (EVN) to work as a single telescope. Originally operated by the JIVE Foundation, established in 1993, it was incorporated as an ERIC in 2015. While JIVE has never been on the ESFRI Roadmap, it is fully operational and is providing data to users and open data access under basic FAIR principles. JIVE is assessed as being at **RL5.** JIVE will continue to operate in support of EVN while at the same time working to extend its relevance globally through involvement in projects such as SKA-VLBI, the Global VLBI Alliance and BLACKHOLECAM.

Long-term Sustainability

JIVE is an established RI with a wide user base and global scientific relevance. The JUMPING JIVE project, which features nine work packages, collectively contributing to advocating VLBI, enlarging the VLBI network and preparing for future challenges and opportunities with VLBI, is addressing future sustainability. Efforts need to continue to achieve agreement on increased contributions from existing member states and to attract new members but if this is not successful then JIVE will continue to rely on EC funding to underpin future operation. Open access to EVN and EVN archived date, which is managed through JIVE is subject to competitive peer review, ensuring **scientific excellence**. EU funding for TA is essential in enabling open access across Europe. In terms of **attracting and training managers, operators and users**, JIVE has benefited from RITrain and from participation in the ERIC Forum. The second edition of the ASTRON/JIVE 'Traineeship in Science Operations with Massive Arrays', part sponsored by JUMPING JIVE was completed in 2019. JIVE encourages users who are not expert in VLBI and provides support for proposal writing and data analysis. JIVE is in the business of supporting curiosity driven science and as such **socio-economic impact** as well as **innovation potential** primarily derive from raising public interest in science and engineering and in attracting young people into STEM subjects. This means that public outreach is very important and JIVE covers this via the JIVE and EVN websites, newsletters and press releases. It is important that this is seen as one of the ERIC's core activities. However, it is not clear that the distinction between JIVE and EVN is helpful in this activity and a single public interface would be preferable. JIVE is actively engaged in **international outreach**, broadening its activities via projects such as SKA and the African VLBI network.

Major Bottlenecks and Possible Measures Which Might impact Further Development
JIVE currently has six member countries, who support 60% of the costs of its activities. The other 40% comes in the form of additional project support for which participation in EU programmes, particularly transnational access is seen as indispensable. A clear bottleneck is the need to ensure that the core activities of JIVE benefit from long-term stable funding from Member Countries. This involves persuading existing members to increase future contributions and attracting new members. Specific activities, supported by the JUMPING-JIVE project, designed to encourage new members and to develop the global appeal and relevance of JIVE are very positive and should clearly continue. The fact that not all European members of EVN are members of JIVE is a clear problem. The correlator and associated data reduction tools are essential elements of any VLBI activity and a governance arrangement that has the correlator funded and governed as a separate RI from the rest of the network, with contributions to the correlator activity seen as separate and perhaps optional is not conducive to long-term sustainability. This is an issue that the members of both JIVE and EVN should consider in the context of future sustainability.
Recommendations
• Ensure that public outreach remains a core activity. • Work with EVN to provide a single and less confusing public interface. • Continue efforts to encourage existing members of JIVE to increase their contributions and to attract new members with the aim of reducing reliance on EU funding. • Work with EVN to explore ways that all members of EVN either become members of the ERIC or make contributions to the operation of JIVE.

LifeWatch ERIC

<table>
<tr><th colspan="2">ENVIRONMENT</th></tr>
<tr><td></td><td>LifeWatch ERIC

e-Infrastructure for Biodiversity and Ecosystem Research</td></tr>
<tr><td colspan="2">LifeWatch ERIC supports the scientific research for the understanding of the complex biodiversity organisation and for the rational management of ecosystems on land and in the seas. It advances biodiversity research by addressing the big environmental challenges and supporting knowledge-based strategic solutions to environmental preservation.</td></tr>
</table>

<table>
<tr><td>Typology RI</td><td colspan="5">Distributed</td></tr>
<tr><td>Lead Country</td><td colspan="5">ES</td></tr>
<tr><td>Members</td><td colspan="5">BE, EL, ES, IT, NL, PT, SI</td></tr>
<tr><td>*Observer (ERIC)</td><td colspan="5">SK</td></tr>
<tr><td>Prospective Members</td><td colspan="5"></td></tr>
<tr><td>ESFRI Roadmap Entry</td><td colspan="5">2006</td></tr>
<tr><td>ESFRI Landmark</td><td colspan="5">2016</td></tr>
<tr><td rowspan="3">Preparation</td><td>PROJECT NAME</td><td>YEAR-YEAR</td><td>EUR M (EU)</td><td>EUR M (Total)</td><td>EUR M (ROADMAP 2018)</td></tr>
<tr><td>LIFEWATCH</td><td>2008-2011</td><td>5.0</td><td>6.4</td><td></td></tr>
<tr><td>TOT</td><td>2008-2011</td><td>5.0</td><td>6.4</td><td>5</td></tr>
</table>

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				142
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	CReATIVE-B	2011-2014	0.7	0.8	
	ENVRI	2011-2014	3.7	5.1	
	COOPEUS	2012-2015	2.0	2.3	
	ENVRI PLUS	2015-2019	14.7	15.0	
	ENVRI-FAIR	2019-2022	19.0	19.0	
	ERIC FORUM	2019-2022	1.5	1.5	
	EOSC-HUB	2018-2020	33.1	30.0	
	COOP+	2016-2018	1.99	1.99	
	ResINFRA	2019-2022	1.5	1.5	
	TOT	2011-2022	78.19	77.19	
Legal Status	ERIC, since 2017				
In Operation since	2017				

Implementation Readiness Level and Future Outlook

LifeWatch ERIC is an ESFRI Landmark in the Operation Phase which has been on the Roadmap since 2006. Governance is in place with responsibilities divided between the Common Facilities: Statutory Seat & ICT e-Infrastructure in Andalucía (ES), Service Centre in Lecce (IT) and Virtual Labs and Innovation Centre in Amsterdam (NL). Although complex the governance seems to have successfully captured various angles of a distributed e-infrastructure. Over the years, LifeWatch has made a good progress also by acting on the recommendations received during various assessments and reviews which proves that people/organisations behind this infrastructure are serious and determined in making it happen. A combination of Preparatory Phase funding as well as several other FP7 and H2020 projects contributed to the development of various parts of LifeWatch. It is assessed at **RL5**. Progress to RL6 will depend on the increase of membership and achieving compliance with FAIR principles for data and services (as will be defined by the EOSC).

Long-term Sustainability

To support its mission “to be a ‘first class’ worldwide provider of content and services for the biodiversity and ecosystem research community”, LifeWatch provides an ecosystem of facilities with data, applications as well as virtual labs and workflows for the data discovery, their curation, management and analysis, modelling and interpretation of the scientific results and, finally, creation of knowledge. To further ensure its **scientific excellence**, the RI puts substantial efforts into attracting and **training their users** with a well-developed training portfolio for users, summer schools and facilities/data visible through three catalogues (virtual labs, data portals (at the moment for Belgium, Greece and Italy) and a catalogue of services). Through the Virtual Laboratories and Innovations Centre, LifeWatch clearly acknowledges its potential to boost technological **innovation** and to open up new fields for socio-economic development. In delivering on **socio-economic impacts** LifeWatch is involved in the ERIC Forum project (one dedicated WP). By bringing knowledge on the impacts from the biodiversity loss and changes in the ecosystem services, LifeWatch offers multimedia educational resources for teachers and students wishing to extend their knowledge of biodiversity and ecosystems. Some of the LifeWatch parts are contributing to the regional economic development through the funding from the EU’s Regional Development Fund as well as part of national Smart Specialisation strategies, for example, in Andalucía in Spain, in Puglia in Italy and in Slovenia. The dialogue with **international** partners is in place as part of the EU-Latin America and the Caribbean Cooperation on Research Infrastructures and a Memorandum of Understanding with AIR Centre (the Atlantic International Research Centre) has been signed. The largest resource offered to their user communities is biodiversity and ecosystems **data**. The data policy elements are in place and the integration to EOSC developing under the ENVRIplus and ENVRI-FAIR projects. Two technological developments aim at making LifeWatch meet FAIR requirements: (a) LifeBlock, the first implementation of BlockChain technology on ESFRI (b) Tesseracto, the basic composability platform for the integration of the web services and applications into workflows. Although there is a clear **governance** structure, the membership has not changed over more than 10 years. With operation costs evaluated at EUR 12M/year it is doubtful for these developments to be covered through existing membership.

Major Bottlenecks and Possible Measures Which Might impact Further Development

The main issue for LifeWatch remains the need to grow its membership and create stronger synergies with other environmental Research Infrastructures. Individual labs/institutes in member Countries also participate (usually separately and not as LifeWatch) in various H2020 projects and even in other ERICs (e.g. EMBRC and ICOS). LifeWatch has an official cooperation with EMSO to work together to design and implement joint research projects and collaborative initiatives and to develop collaborative plans with DiSSCo and eLTER, the Research Infrastructures which have just recently joined the ESFRI Roadmap, and major aggregators such as GBIF and CoL. Despite all these efforts, a crucial challenge of capacity and scale of LifeWatch and a need for substantial integration remains to be met.

Recommendations

- Work with EMBRC, ICOS, EMSO and other RIs to implement state-of-the-art e-infrastructures focusing on interoperability as a key element (also for long-term sustainability) beyond the life of the cluster projects.

- In light of potential duplication of efforts LifeWatch should work with EMBRC, ICOS, EMSO and other RIs to clarify the roles of labs/institutes participating in multiple RIs.

- Coordinate better the national funding used for the distributed centres to optimise LifeWatch as a pan-European RI.

- Develop an engagement plan to secure funding beyond in-kind contributions and from more members. A review of LifeWatch's added value in comparison with a network of facilities should be part of this, including identifying complementarities with other RIs.

- Task the Statutory Seat and the ICT Core e-Infrastructure to "translate" the mission into a set of scientific/operational KPIs and report on those to the RI governance. Progress towards making data FAIR should also be part of the KPIs.

- Task the Service Centre to make easily visible and available, an access policy to LifeWatch facilities in line with the EU Charter on Access to RIs. Simplify the offer to users which is currently via multiple catalogues.

- Develop an Innovation Strategy focusing not only on the innovative aspects of RI (like the already visible blockchain technology) but also in terms of industry attraction.

- Develop and communicate socio-economic impact examples. These should include examples/success stories of activities that their user communities managed to achieve in terms of innovation, engagement with industry, business, and public sector.

MIRRI

HEALTH & FOOD	
	MIRRI **Microbial Resource Research Infrastructure**

MIRRI is a distributed Research Infrastructure that will provide microbiological services, facilitate access to microorganisms and associated data. It aims to coordinate the pan-European infrastructure, manage microbial resources to support various areas of research and drive the collaboration across disciplines and European countries in order to unify of resources and services and eliminate duplications and redundancies at the national and European levels. Its mission when realised will benefit a wide variety of research fields (health, biotechnology, food and agriculture, life sciences) by coordinating the distribution of microbial sources and standardised data.

Typology RI	Distributed				
Lead Country	ES, PT				
Members					
***Observer (ERIC)**					
Prospective Members	BE, EL, ES, FR, IT, LV, NL, PL, PT, RU				
ESFRI Roadmap Entry	2010				
ESFRI Landmark					
Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	MIRRI	2012-2016	3.1	4.1	
	TOT	2012-2016	3.1	4.1	3.1

Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	IS_MIRRI21	2020-2023	4.9	4.9	
	TOT	2020-2023	4.9	4.9	0.8
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	BIOMEDBRIDGES	2012-2015	10.5	13.7	
	EMBRIC	2015-2019	9.0	9.0	
	CORBEL	2015-2020	14.8	14.8	
	RI-VIS	2019-2021	1.5	1.5	
	EOSC-Life	2019-2023	23.7	23.7	
	TOT	2012-2023	59.5	62.7	
Legal Status	Pending				
In Operation since	Foreseen 2021 (Currently in Implementation Phase, ESFRI Project)				

Implementation Readiness Level and Future Outlook

MIRRI has been an ESFRI Project since 2010. During the Preparatory Phase, involving 16 Partners and 28 Collaborating Parties from 19 countries, a brief financial plan as well as partner charter were prepared. MIRRI aims to get the ERIC legal status, but it took until 2018 for eight prospective member Countries to agree for Portugal to host the statutory seat of the future ERIC and for Spain to host the Collaborative Working Environment hub. MIRRI is entering into its Construction Phase with some of the partners also being involved in other RI-linked projects like EMBRIC, CORBEL and RI-VIS. MIRRI is assessed at **RL3**. Substantial efforts need to be spent on developing a feasible “business model” to move towards RL4.

Long-term Sustainability

ESFRI reviewed MIRRI in 2017 and rated its **scientific excellence** as medium. Since then, MIRRI prepared a Strategic Plan to address scientific goals focusing on supply of microbiological resources, research, and bioeconomy. To attract users, MIRRI provides links to the online catalogues and gives an overview of the services provided by participating collections, but this is not yet via the single portal that was envisaged. Additionally, MIRRI explicitly states that they are not responsible for the content of external pages and the users can also go directly via microbial domain Biological Resource Centres (mBRCs) or via the national nodes. The website is being revamped (due to be launched in early 2020) to provide a more user-focused service and a transnational access pilot will be launched under IS_MIRRI21. To unlock the **innovation** potential MIRRI participated in the actions of EMBRIC, whose objective was to foster innovation in marine biotechnologies through cross-cutting training and knowledge transfer as well as a pilot of transactional access. It is not clear to what extent the innovation was achieved and whether it is reflected in the use of MIRRI services. MIRRI's approach and steps towards measuring **socio-economic impacts is not clear,** in spite of MIRRI's great potential for human and animal health, food, biotechnology, and agriculture. For structuring the **international outreach** beyond the EU, MIRRI has signed a MoU with Russia, and expressions of interest with Chile and Brazil. Interoperability of **data** was identified as a major challenge at the Preparatory Phase. As part of EOSC-Life, MIRRI is focusing on establishing an integrated database, but it is not entirely clear how the team is working on data management plan (DMP), EOSC integration or on making its data FAIR. The envisaged future **governance** is very complex with Central Coordinating Unit (CCU), Collaborative Working Environment Hub, national nodes, individual mBRCs, MIRRI Expert Clusters. This raises the question of how the RI is really different from cluster activities of, for example, EMBRIC with its European Blue Biobank. The agreement on funding is not in place. More countries signed MoU (IT and RU) and BG, CZ, SK, IE, Chile and Brazil expressed interest. Germany and the UK, as two key focus countries in the beginning, have withdrawn.

Major Bottlenecks and Possible Measures Which Might impact Further Development

Since the 2013 AEG review and the end of the Preparatory Phase project in 2016 MIRRI has not shown substantial progress. A clear vision/justification for a Research Infrastructure as opposed to a coordinated network of individual partners is lacking as is as a clear financial model and sufficient long-term commitment from the member States. The slow progress in bringing potential members to firm agreement is largely linked to the unclear added value of this RI and of a dedicated team fully focused on MIRRI. Signed MoUs do not necessarily lead to membership in an ERIC and to commitment of funds. The initial key people behind MIRRI's idea are not involved any longer. It is also unclear why national nodes need a CCU if they all have their own legal structure (as envisaged by MIRRI) and they will stay independent in addressing user needs in their own Country. Displaying services/expertise on the new website does not equal 'an offer' to potential users. Despite this MIRRI is participating in several other RI-related projects and engaging in other important topics (such as EOSC and international outreach). This does not come across as a sensible use of the available resources that should focus on the most crucial topic for MIRRI's long-term sustainability i.e. critical size of membership and robust financial planning.

Recommendations

Within the remit of the new IS_MIRRI21 project:

- Develop a clear service offering and a value proposition to all stakeholder groups and, based on that, build a plan to bring the attention and interest of new potential members. Focus on the unique value proposition of service offering that MIRRI is bringing to its users that cannot be provided by the individual member organisations.

- Explain the complementarity of national instruments contributing to the future MIRRI and how the links to instruments which are not part of MIRRI (e.g. Germany) will be ensured.

- Explain the complementarity of work vis-à-vis BBMRI (on developing international standards in the field of biobanking) and LifeWatch.

- Secure a written commitment for funding from prospective ERIC members. In developing a financial plan, include realistic cost analysis (especially against such intensive activities as interoperability of data).

- Develop an action plan for MIRRI to become an infrastructure of reference in microbiology.

- In simplifying access rules, ensure excellence driven mode of access regardless of origin. Introduce and make publicly visible via annual reports performance indicators (also linked to scientific production), monitoring (also at the level of national nodes/mBRC) and reporting to the RI's governance. The indicators must include the RI's production of scientific outputs.

- If the results of IS_MIRRI21 project do not bring memberships/financial support, either reorient MIRRI into a network of facilities, or explore synergies with existing infrastructures (e.g. LifeWatch) and investigate the opportunity to deliver on the MIRRI objectives via LifeWatch, BBMRI or existing projects, such as Microbiome Support and EMBRC's EBB. Currently, there is a clear overlap in institutions/facilities and activities.

SHARE ERIC

SOCIAL & CULTURAL INNOVATION

SHARE ERIC

Survey of Health, Ageing and Retirement in Europe

SHARE builds an infrastructure of micro data necessary to understand individual and societal ageing as a process in time that is strongly influenced by pension, health care and labour market regimes and their reforms. It is designed by researchers for researchers and integrates economics, medicine, and social sciences data. Research based on this infrastructure will also serve as a feedback mechanism to support fact-based EU policies, such as the open method of coordination and the Lisbon agenda, to help meeting the challenges of population ageing in all countries of the EU.

Typology RI	Distributed
Lead Country	DE
Members	AT, BE, BG, CY, CZ, DE, EL, FR, HR, HU, IL, IT, NL, PL, SE, SI
***Observer (ERIC)**	CH
Prospective Members	
ESFRI Roadmap Entry	2006
ESFRI Landmark	2016

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	SHARE	2002-2004	2.8	3.1	
	SHARE I3	2006-2008	5.8	5.8	
	SHARE-PREP	2008-2009	2.5	3.7	
	SHARE_LEAP	2009-2010	3.0	4.1	
	TOT	2002-2010	14.1	16.7	NA
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	SHARE_M4	2011-2014	5.5	7.7	
	SHARE-DEV3	2015-2019	5.5	5.5	
	TOT	2011-2019	11.0	13.2	NA
Collaborative Grants	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.	DASISH	2012-2014	6.0	8.3	
	SERISS	2015-2019	8.5	8.9	
	RITRAIN	2015-2020	2.0	2.0	
	ERIC FORUM	2019-2022	1.5	1.5	
	SSHOC	2019-2022	14.5	14.5	
	TOT	2015-2022	32.5	35.2	

Legal Status	ERIC, 2011
In Operation since	2011

Implementation Readiness Level and Future Outlook

SHARE is an ESFRI Landmark and has been on the roadmap since 2006. SHARE is a long-established RI that has developed a longitudinal multi-national survey that has contributed to the study of aging in the EU. By the time SHARE entered the ESFRI Roadmap the second survey wave was already underway, funded through the FP6 SHARE-I3 project. In addition to the members, participating countries include: DK, EE, ES, FI, LT, LV, MT, PT, RO. The SHARE Annual Activity Report indicates that the number of registered users growing and that publications are also healthy. It also provides evidence of the impact on policy making (a primary impact of SHARE). In March 2011, SHARE was incorporated as the first ERIC. It is fully operational and provides open data access to users. Accordingly, SHARE is assessed it as being at **RL5**. SHARE is active in the SERISS project to exploit synergies in social science infrastructure and in the Social Sciences and Humanities Open Cloud (SSHOC) and is considered to be heading towards **RL6**.

Long-term Sustainability

SHARE has engaged about EUR 200 M in the period 2002-2020, mostly from national contributions, EU funding and international grants. SHARE's own assessment is that it meets all of the sustainability preconditions in many EU Member States but not in all Member States. **Scientific Excellence** is enshrined in the SHARE-ERIC statutes and the quality of SHARE data has been independently, scientifically reviewed. Both the number of registered users and the publications resulting from SHARE data are high and continuously increasing. Key to maintaining the quality of SHARE data is the **training** of scientists, managers and fieldworkers and SHARE puts a great deal of emphasis on this activity as well as on the training of users across Europe. While the SHARE Annual Activity Report provides evidence of the impact of the RI on policy making in Europe and more widely, there would be a benefit in an independent assessment of SHARE's **socio-economic impact**, primarily as a result of impact on policy makers. Such an assessment could also cover the **innovation potential** primarily focussing on the downstream effects on services aimed at tackling the issue of aging populations. Regarding **data**, SHARE's approach is in line with FAIR data principles. SHARE is embedded in a global network of sister studies, such as the Health and Retirement Study (HRS) in the US and the English Longitudinal Study of Ageing (ELSA). Harmonized questionnaires guarantee comparability of data around the world.

Major Bottlenecks and Possible Measures Which Might impact Further Development

It is clear that EU funding has been essential both to the establishment of the SHARE-ERIC as a Research Infrastructure and to funding the 8 waves of data collection. Since SHARE is a long-term panel study that observes changes over time, its ambition has been to include all EU member states in as many waves of the survey as possible without interruptions. Funding has been, and continues to be, a significant bottleneck to achieving this aim with the lack of secure funding in smaller, less wealthy Member States continuing to threaten participation across Europe and the long-term sustainability of the RI. Continued efforts are needed to ensure that SHARE is adopted on National Roadmaps. Efforts should be continued to reach out to the public as well as policy makers across Europe via newsletters and press articles to raise awareness of the value that SHARE offers for informing decision making.

Evidence gathered through SHARE is increasingly used for policy making purposes at national, European and global levels. In this respect, wider EU funding from sources other than RTD have been important in widening participation. However, without continuation of funding from additional sources sustainability cannot be assured. The Long-Term Sustainability Staff Working Document noted in relation to SHARE that 'RI, contributing to EU policy making, currently lack a specific type of EU support, to promote the use of these ERICs collecting and sharing data resources, such as data archives, to researchers benefiting from EU support like Horizon 2020'. For SHARE, the long-term sustainability goal has a dimension that goes beyond what can be addressed by the RI alone and this needs to be actioned at a higher level.

Recommendations

- Maintain the pressure for adoption of SHARE in all national roadmaps in order to obtain cross-national alignment of funding strategies.
- Consider an independent assessment of the socio-economic impact and innovation potential of SHARE which could potentially add to the funding negotiations with current and future members.
- Maintain communication efforts to engage with the general public and policy makers in all participating and non-participating countries to increase awareness of SHARE and its potential impact beyond academia.
- Promote the concept of SHARE as a pillar for broader internationalization of Research Infrastructures on ageing that provides access to data and methods to the Global Science Forum.

WindScanner

ENERGY	
WindScanner.eu	**WindScanner** **European WindScanner Facility**
The European WindScanner Facility project was established to maintain European technological leadership in high-resolution remote sensing methodologies for full-scale real atmospheric wind and turbulence measurements. The aim is to investigate complex flow and turbulence, which create loads and cause fatigue in wind turbines and wind plants in operation. The WindScanner system generates 3D detailed maps of wind conditions around single wind turbines and a farm covering several square kilometres. Laser-based devices called Light Detection and Ranging (LiDARs) are used to measure wind fields and turbulence conditions. WindScanner aimed to upgrade the European nodes with this modern LiDAR technology.	

Typology RI	Distributed
Lead Country	DK
Members	DK
***Observer (ERIC)**	
Prospective Members	
ESFRI Roadmap Entry	2010
ESFRI Landmark	

Preparation	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	WINDSCANNER	2012-2015	4.4	6.2	
	TOT	2012-2015	4.4	6.2	5.9
Implementation/ Construction	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	**EUR M (ROADMAP 2018)**
	TOT				6.1
Collaborative Grants *Please note these are total sums, without breakdown for individual beneficiaries. For the rationale of presenting these figures, please go to page 71.*	**PROJECT NAME**	**YEAR-YEAR**	**EUR M (EU)**	**EUR M (Total)**	
	TOT				
Legal Status	Pending				
In Operation since	Foreseen 2021				

Implementation Readiness Level and Future Outlook

WindScanner has been on the ESFRI Roadmap since 2010. Despite a Preparatory Phase project WINDSCANNER which brought together ten partners from seven Countries to develop a governance scheme, legal model, the final technological design and associated budget and financing models for the construction of the Research Infrastructure by 2016, WindScanner still has only one member. Some activities are happening at the national level of the participating countries, e.g. WindScanner.PT,which as a project running until 2020 and aims to build the Portuguese node for WindScanner.EU. Since the conclusion of the WindScanner Preparatory Phase project in 2015, many instruments have been built and deployed in measurement campaigns especially in Denmark and Germany but also in the ERANET+ project New European Wind Atlas. However, very little has been done to further develop the idea of WindScanner as a pan-European distributed (and mobile) Research Infrastructure. WindScanner is assessed as being at early stages of **RL2** and cannot progress to RL3 without a viable consortium in place.

Long-term Sustainability

WindScanner's **scientific** long-term vision is not entirely clear and user engagement is only slowly progressing and not well addressed despite these being identified as bottlenecks already in the 2013 Assessment Expert Group (AEG), 2015 ESFRI Implementation Group (IG), and 2016 ESFRI reviews. One of the proposed value propositions for the future central hub of WindScanner was in designing and delivering 'an education scheme' for technicians and scientists to help them build and operate the scanners as part of their national WindScanner node. However, due to the lack of funding available through the involvement in the national roadmaps, this has not yet materialised. With regard to better exploiting the data generated by WindScanner, the value added of using a central hub for data storage is not clear. WindScanner has potential for **international collaborations** as its technology (Spinner LiDAR) was tested for a year on the NREL CART3 in the USA, followed by a wake field measurement program, also for another full year at SWIFT, Texas, and a short-range WindScanner has been delivered to the Canadian WindEEE Research Institute. Despite efforts made during the Preparatory Phase project, the commitment from the partner Countries for **governance** and **financial** contributions has not yet been realised. Although more Countries have provided their support on paper, outside Denmark the only WindScanner activities appear to be those undertaken in Germany (via an individual project funding) and Portugal. After the Preparatory Phase, the consortium planned to continue on the basis of an interim structure (a framework of involvement through EERA (European Energy Research Alliance) which has a proven governance structure). The use of the proprietary LiDAR technology has the potential to generate **socio-economic impacts**, for example, by making plane landings safer through measuring wind shear and turbulence along runways and optimising the design of wind turbines leading to cheaper wind energy. At the current stage of development, WindScanner could unlock **innovation** potential. As part of the original project WindScanner.dk run by the Technical University of Denmark (DTU) with participation from other research institutions as well as wind energy companies, developed a proprietary LiDAR technology. This technology is the key asset of WindScanner and could in time be broadened by involving, for example, the next generation of wind radars and other types of measurement and data. LiDAR and further technologies could help address the needs of the European wind energy community for measurements of the 3-D wind field surroundings and lead to a more optimal design of the wind turbines and hence to cheaper wind energy.

Major Bottlenecks and Possible Measures Which Might impact Further Development
WindScanner, although having a promising and tested technology with several applications, has major difficulties in establishing itself as a RI with a strategy for long-term sustainability. No clear value proposition for the RI has been developed over the last ten years which is a bottleneck for securing national funds. The team behind WindScanner must address a fundamental question about the nature of WindScanner and whether the benefits of the developed technology could be better taken forward commercially through licensing deals or a start-up / spin-off company. Partners may also wish to investigate whether EERA might offer WindScanner services as part of their core offering.
Recommendations • Given their strong innovation potential, the team behind WindScanner should reassess its position on the ESFRI Roadmap and whether commercialising the LiDAR technology provides a better means of longer-term sustainability. The DTU team behind WindScanner should discuss possible commercialisation options with the DTU Tech Transfer team and the European Commission's Dissemination & Exploitation Booster's Service 2: Business Plan Development and Service 3: Go-To-Market Support. • Explore the potential for EERA to take WindScanner mobile infrastructure and its services under its wing. LiDAR technology can be offered as part of Joint Programme WIND on a fee-for-service (or other commercial) basis, including deploying it as a mobile emergency unit to sites where wind turbines are experiencing problems. • Develop a long-term scientific vision and plan of WindScanner as a pan-European Research Infrastructure, including a robust list of annual KPIs for the next 3 years, suitable for revision by ESFRI. • Estimate the demand for WindScanner technology and services and, based on that, prepare a detailed business plan, incl. financial planning.

Annex 1. The High Level Expert Group

Chair

Prof. Giorgio Rossi

Prof. Giorgio Rossi, of the Physics Department of the Università degli Studi di Milano, is an expert in Research Infrastructure policy and management. A former ESFRI Chair, he is currently a member of the EOSC Governing Board. He coordinates European and Italian RIs on nanoscience.

Members

Dr. Jelena Angelis

Dr. Jelena Angelis is an expert in the formation and implementation of research and innovation policy and supporting instruments, and a Research Director at the European Future Innovation System (EFIS) Centre, a not-for-profit policy research centre in Brussels.

Dr. Filipa Borrego

Dr. Filipa Borrego is the Innovation Management Coordinator at INESC-ID. She was part of the team working on the first edition of the Portuguese Roadmap of Research Infrastructures and has been an expert reviewer and rapporteur of several competitive European funding instruments.

Dr. Joy Davidson

Dr. Joy Davidson is the Coordinator for the UK's Digital Curation Centre (DCC) - a Research Infrastructure specialised in data management planning, curation and Open Science. Joy currently leads WP3 of the EC funded FAIRsFAIR project, which aims to increase the production and use of FAIR data. She has been involved in reviews for previous ESFRI Roadmaps and several H2020 Research Infrastructure funding programmes.

Dr. Elena Hoffert

Dr. Elena Hoffert is a scientific advisor at the department of Research Infrastructures at the French Ministry for Higher Education, Research and Innovation. She coordinates the update of the national roadmap and strategy on Research Infrastructures, and is the French delegate at ESFRI and the H2020 Program Committee configuration on Research Infrastructures.

Dr. Richard Wade

Dr. Richard Wade is an Independent Science and Technology Management Consultant with a background in the design, funding and governance of Research Infrastructures.

Annex 2. Terms of Reference

European Commission high level expert group to assess the progress of ESFRI and Other World Class Research Infrastructures towards implementation and long-term sustainability

Context

Research Infrastructures[25] (RI) are a key component of the European Research Area (ERA) and play an essential role in the advancement of knowledge and technology. They contribute to the full spectrum of science by offering services that enable discovery, technology development and invention. They drive technological progress, which depends on both transformative research and innovation.

Europe has a long tradition of scientific excellence and has built a worldwide reputation in RI. This has been made possible by pursuing national investments and more recently by developing a coherent and strategy-led approach to policy making on pan-European RI development.

The European Strategy Forum on Research Infrastructures (ESFRI) has been successful in developing a medium to long-term vision on the needs of the European scientific communities, which led to the consolidation of a roadmapping process at European level. In addition, the European Research Infrastructure Consortium (ERIC) Regulation has also significantly contributed to the structuring of the European RI ecosystem.

This strategic approach of RI development has generated clear advantages, such as avoiding duplication of efforts, pooling resources, rationalising RI use, standardising processes and procedures as well as consolidating the global leadership of European RI. Advantages of such a European approach are also illustrated in the EU Reflection Paper on the future of EU finances, where this approach is "*a clear value added when action at European level goes further than national efforts (...) Cross-border programmes have transformed border areas helping to remove sources of conflict and create new economic opportunities*[26]".

[25] The term 'Research Infrastructures' refers to facilities, resources or services of a unique nature that have been identified by European research communities to conduct top-level activities in all fields of science. This definition includes the associated human resources, covers major equipment or sets of instruments, in addition to knowledge-containing resources such as collections, archives and data banks. RI may be located in a single site (for example, large telescopes, Synchrotrons, High Performance Computing) or can be distributed across even large number of sites working jointly (for example, biobanks, archives, marine stations).

[26] EU Reflection Paper on the future of EU finances, June 2017, p. 12
http://ec.europa.eu/budget/mff/hlgor/library/reports-communication/hlgor-report_20170104.pdf

However, putting into place and maintaining such a landscape of excellent RI serving the needs of the scientific communities and other stakeholders has a price. Many RI (especially the large physics and analytical facilities) require substantial investments from Member States with construction price tags that can go well beyond a billion Euro and related operational cost that, on average, on a yearly basis, amount to around 10% of their construction value. The increasing number of implemented pan-European RI, such as the ESFRI projects and the ERICs, weighs therefore more and more on the national science budgets, hence raising the question of their long-term sustainability[27].

Stakeholders consultations held in 2016 have highlighted that sustainability of RI goes well beyond funding, touching upon several dimensions such as scientific excellence, socio-economic impact or innovation, among others. The EC Staff Working Document on Research Infrastructures Long-Term Sustainability – EC SWD (2017) 323 – provided a comprehensive overview of the pre-conditions to be addressed at European level over the entire RI life cycle - from initial planning up to phasing out and termination.

Long-term sustainability is therefore a key element for developing a coherent European RI policy and landscape.

To date, 57 RIs have been identified to be of pan-European (or global) relevance. These are the 55 RIs that are included in the ESFRI Roadmap (37 Landmarks, 18 Projects) and two ERICs (JIVE ERIC and CERIC ERIC), that were given the ERIC status by European Commission Decision after assessment by the Commission services and a positive opinion of the ERIC Committee.

These 57 RIs are in different stages of their lifecycle, but will benefit from a thorough assessment at a given moment in terms of long-term sustainability and could provide a snapshot of the development of the landscape of pan-European RIs beyond 2020.

Objectives

Against the background described above, the European Commission has decided to set up a high-level expert group to focus on two complementary objectives in relation to the 57 RIs mentioned above:

1. Assessment of the effectiveness of the RI funding instruments under the Union Framework Programme:

- Assess the effectiveness of the Framework Programme funding instruments, in particular the Preparatory Phase funding for RIs in early phases of their lifecycle,

[27] The definition of RI sustainability is the one adopted by the OECD and the European Commission which defines it as the capacity for a Research Infrastructure to remain operative, effective and competitive over its expected lifetime.

the individual support for fostering their implementation and enhancing their sustainability;

- provide recommendations, where appropriate for improvements.

2. Assessment of the RI progress towards implementation and long-term sustainability:

- Evaluate the future outlook of the pan-European (or global) relevance RIs in relation to their scientific goals and the evolution in their lifecycle;
- identify major bottlenecks and possible measures which might impact their further development,
- provide recommendations on the basis of the assessment and evaluation set out above in line with the Long-term sustainability pre-conditions[28], namely:
    - » Critical mass and added value of the RI (in comparison with a network) and prospection of new members,
    - » Key Performance Indicators and Socio-Economic Impact
    - » Catalogue of services and service-driven approach,
    - » User communities and outputs also in terms of innovation and TRLs,
    - » Capacity to maintain leadership and excellence in terms of instrumentation and services in relation to scientific and technical developments,
    - » Complementarity of the activities of the RIs and possibilities for consolidation with overlapping/related RIs
    - » Effectiveness of embedding international partners in the RI and of the cooperation with relevant international partners

[28] The European Commission Staff Working Document SWD(2017) 323 and the preceding consultation process were based on interrelated conditions for sustainability of RI:

- Ensuring scientific excellence
- Attracting and training managers, operators and users of tomorrow,
- Unlocking the innovation potential of RI,
- Measuring socio-economic impact of RI,
- Exploiting better the data generated by the RI,
- Establishing adequate framework conditions for effective governance and sustainable long-term funding for RI at every stage in their life-cycle,
- Structuring the international outreach of RI.

Concerning the Assessment of RI progress towards implementation and sustainability, the high-level expert group will assess the long-term sustainability pre-conditions against a sub-set of the 57 RIs. The assessment will not address new 2018 ESFRI Projects, nor data infrastructures such as PRACE and nuclear RIs such as the Jules Horowitz Reactor.

The High-Level Expert Group will also assess RIs operated by intergovernmental organisations (EIROs) even though their sustainability must be addressed differently in view of their specific governance and funding structure.

The European Commission will ensure complementarity with other ongoing evaluations and assessments of ESFRI Projects and/or Landmarks.

Annex 3. A full list of RIs in this Assessment

The Terms of Reference for the HLEG noted that 57 RIs had been identified to be of pan-European (or global) relevance. These were the 55 RIs that are included in the ESFRI Roadmap (37 Landmarks, 18 Projects) and two ERICs (CERIC ERIC and JIVE ERIC).

During the first stage of HLEG activity – which took place between March and August 2019 – to address Objective 1 (assessing the effectiveness of the Research Infrastructure funding instruments under the Union Framework Programme), the focus of the HLEG's work was on a subset of 54 RIs as some special cases such as nuclear RIs (JHR, MYRRHA) and PRACE are differently guaranteed in terms of sustainability and were not considered further.

During the second stage of the HLEG activity – which ran from September 2019 to January 2020 – the 5 RIs managed by EIROforum members were assessed as a separate group due to the different conditions for their long-term sustainability. Out of the remaining 49 RIs, those 6 that entered the ESFRI Roadmap in 2018 were excluded, leaving a list of 43 RIs to be individually assessed to address Objective 2 (assessing the RI progress towards implementation and long-term sustainability).

The list of the 57 RIs studied, including those managed by EIROforum members and the ESFRI Projects 2018, is reported (A=Assessed, NA=Not Assesses, EIRO=EIROforum).

RESEARCH INFRASTRUCTURE	CATEGORY	TYPE	
LANDMARK			
Energy			
ECCSEL ERIC	Landmark	Distributed	A
JHR	Landmark	Single-sited	NA
Environment			
EISCAT_3D	Landmark	Single-sited	A
EMSO ERIC	Landmark	Distributed	A
EPOS ERIC	Landmark	Distributed	A
EURO-ARGO ERIC	Landmark	Distributed	A
IAGOS	Landmark	Distributed	A
ICOS ERIC	Landmark	Distributed	A
LifeWatch ERIC	Landmark	Distributed	A
Health & Food			
BBMRI ERIC	Landmark	Distributed	A
EATRIS ERIC	Landmark	Distributed	A
ECRIN ERIC	Landmark	Distributed	A
ELIXIR	Landmark	Distributed	A
EMBRC ERIC	Landmark	Distributed	A
ERINHA	Landmark	Distributed	A
EU OPENSCREEN ERIC	Landmark	Distributed	A

Euro-BioImaging ERIC	Landmark	Distributed	A
INFRAFRONTIER	Landmark	Distributed	A
INSTRUCT ERIC	Landmark	Distributed	A
Physical Sciences & Engineering			
CTA	Landmark	Single-sited	A
ELI	Landmark	Single-sited	A
ELT	Landmark	Single-sited	EIRO
EMFL	Landmark	Distributed	A
ESRF EBS	Landmark	Single-sited	EIRO
European Spallation Source ERIC	Landmark	Single-sited	A
European XFEL	Landmark	Single-sited	EIRO
FAIR	Landmark	Single-sited	A
HL-LHC	Landmark	Single-sited	EIRO
ILL	Landmark	Single-sited	EIRO
SKA	Landmark	Single-sited	A
SPIRAL2	Landmark	Single-sited	A
Social & Cultural Innovation			
CESSDA ERIC	Landmark	Distributed	A
CLARIN ERIC	Landmark	Distributed	A
DARIAH ERIC	Landmark	Distributed	A

ESS ERIC	Landmark	Distributed	A
SHARE ERIC	Landmark	Distributed	A
PRACE	Landmark	Distributed	NA
PROJECTS			
Energy			
EU-SOLARIS	Project	Distributed	A
IFMIF-DONES	Project	Single-sited	NA
MYRRHA	Project	Single-sited	NA
WindScanner	Project	Distributed	A
Environment			
ACTRIS	Project	Distributed	A
DANUBIUS-RI	Project	Distributed	A
DiSSco	Project	Distributed	NA
eLTER	Project	Distributed	NA
Health & Food			
AnaEE	Project	Distributed	A
EMPHASIS	Project	Distributed	A
EU-IBISBA	Project	Distributed	NA
ISBE	Project	Distributed	A
METROFOOD-RI	Project	Distributed	NA
MIRRI	Project	Distributed	A

Physical Sciences & Engineering			
EST	**Project**	**Single-sited**	**A**
KM3NeT 2.0	**Project**	**Single-sited**	**A**
Social & Cultural Innovation			
E-RIHS	**Project**	**Distributed**	**A**
EHRI	**Project**	**Distributed**	**NA**
OTHERS			
CERIC ERIC	**Other**	**Distributed**	**A**
JIVE ERIC	**Other**	**Distributed**	**NA**

Annex 4. Evolution of specific H2020 RI funding instruments

To deliver the broad objectives of supporting RIs in H2020, specific funding calls were introduced including:

- Developing [and long-term sustainability] of new world-class/pan-European Research Infrastructures (INFRADEV),
- Integrating and opening Research Infrastructures of European interest (INFRAIA),
- E-Infrastructures (EINFRA),
- Support to innovation, human resources, policy and international cooperation (INFRASUPP),
- Clusters to foster the cooperation between RIs.

Table 1. Design Studies call text

Design Studies - call text	WP 2014-2015[29]	WP 2016-2017[30]	WP 2018-2020[31]
Scientific and technical work	Drafting concepts and plans for construction and creation of prototypes; focus on maximising use of facility from the start with high efficiency.	Text as stated in WP 2014-2015 but new reference to resource efficiency and environmental impacts.	Text as stated in WP 2015-2016 but new reference to data curation, preservation and access in line with FAIR principles.
Strategic work	Plans to integrate harmoniously with related European facilities; identification of site(s); estimated budget for construction and operation; design of workable legal and governance structure; plans for services to be provided at international level.	Text as stated in WP2014-15 but 'harmoniously' changed to 'coherently'; new reference to 'international' governance structure.	Text as stated in WP 2015-16 but with new reference to include initial ideas on how to achieve long-term sustainability.

[29] Work Programme 2014-2015
http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-infrastructures_en.pdf

[30] Work Programme 2016-2017
http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-infrastructures_en.pdf

[31] Work Programme 2018-2020

http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-infrastructures_en.pdf

Table 2 – Preparatory Phase of ESFRI projects call text

Preparatory Phase of ESFRI projects - call text	**WP 2014-2015**	**WP 2016-2017**	**WP 2018-2020**
Type of RI and scope	Preparatory Phase type I: Proposals will address Research Infrastructures identified in the periodic updates of the **ESFRI roadmap** or in the European strategy for particle physics, that are willing to set up a pan-European **governance** and **legal structure** (e.g. in the form of an ERIC).	Preparatory Phase for Research Infrastructures which entered the active project list of the **ESFRI roadmap in 2016**. Aims to bring the project to the level of legal, financial, and, where applicable, technical **maturity** required for implementing it. Funded as CSA. Call text updated to make clear that the preparation of the **legal and financial agreements** should be key activities and deliverables and should **be finalised before the end of the project** (e.g., through the signature of a Memorandum of Understanding). A **detailed list of activities** that can be included in a Preparatory Phase proposal was provided in part A of the section 'Specific features for Research Infrastructures'. Proposals asked to explain **synergies** and **complementarities** with previous or current EU grants.	Preparatory Phase for new Research Infrastructure projects which enter the **ESFRI Roadmap in 2018.** Aims and expectations as stated for 2016-2017 call but new reference stating that **societal and economic benefits** of the infrastructure should be analysed to carry out a **cost-benefit analysis**

Type of RI and scope	Preparatory Phase type II: Targets new Research Infrastructures projects, which have **already been supported by EU** through a first Preparatory Phase grant and have not yet entered in Implementation Phase.	Support to Early Phase for Research Infrastructures which entered the **ESFRI roadmap in 2016** as emerging projects. Aims to bring an **emerging ESFRI project** to the level of **maturity** required for being in the active project list. Funded as RIA.	Support to Early Phase for Research Infrastructure initiatives in high strategic potential areas of research identified in the **ESFRI Roadmap 2018**. Aims to foster the development of pan-European Research Infrastructures in areas demonstrating particularly **high strategic potential** for the European Research Area.

Table 3 – Individual implementation and operation of ESFRI projects call text

Preparatory Phase of ESFRI projects - call text	WP 2014-2015	WP 2016-2017	WP 2018-2020
Scope	Targets the implementation and initial operation of new **RIs which are identified by ESFRI**, in the context of the prioritisation exercise, as essential to extend the frontiers of knowledge in the fields concerned and **mature enough** to be under implementation by 2015-2016. Support for implementation and initial operation activities, such as enlargement of the membership, enhancement of the technical architecture, development of innovative components, central coordination, access provision, data management (including possible open access to data), training, outreach, **international cooperation, research and innovation activities**. Specific attention will be given to the interaction with end-users (notably **industry and SMEs**). Activities may also foster the development of **Regional Partner Facilities. Infrastructures**.	Targets the long-term sustainability of new RIs, ESFRI and other world class Research Infrastructures (OWCRI) in Europe, with **established governance and legal structure**, notably on the basis of the **ERIC** or any other suitable structure. Support will be provided to activities aimed at **ensuring long-term sustainability**, including enlargement of the membership, European coverage, international cooperation, limited pilots of access provision for testing and improving user services to increase reliability and create trust, definition of service level agreements and business/funding plan, outreach, and technology transfer activities. Proposals should explain any **synergies and complementarities** with previous or current EU grants.	Call text as stated in 2016-2017 highlighting interaction with industry and SMEs but with an **emphasis on fostering the innovation potential** of the infrastructures.

Fast-tracking the implementation of an ESFRI Research Infrastructure (INFRADEV-04-2019)	N/A	N/A	Targeted call to **accelerate the implementation** and operation of the Extreme Light Infrastructure (ELI) project.

Table 4 – Clusters call text

Clusters	Implementation and operation of cross-cutting services and solutions for clusters of ESFRI and OWSSI WP 2014-2015 EUR 80 million	Connecting ESFRI infrastructures through Cluster projects WP 2018-2020
Scope	This topic will **contribute** to the **construction** and **operation** of the Research Infrastructures identified in the ESFRI Roadmap, therefore proposals must be centred and built around **ESFRI projects** in a specific thematic area that is broad enough to gather critical mass (e.g. Biomedical Science, Advanced Light Sources, Astronomy, Environment and Earth Sciences). Proposals should develop **synergies** and **complementarity**, optimise technological implementation, define workflows and ensure coordination, **harmonisation**, **integration** and **interoperability** of data, applications and other services between the ESFRI and other Research Infrastructure initiatives in specific thematic areas.	This topic will ensure the **connection** of the Research Infrastructures identified in the ESFRI Roadmap **to the EOSC**. Support to this activity will be provided through cluster projects gathering **ESFRI projects** and landmarks in each of the following large thematic domains: Biomedical Science, Environment and Earth Sciences, Physics and Analytical Facilities, Social Science and Humanities, Astronomy, Energy. Proposals will address the **stewardship of data** handled by the involved Research Infrastructures according to the **FAIR principles** and in line with the objectives of Open Science.

	Proposals may address the **development of skills** and the specific training of staff managing and operating the Research Infrastructures, as well as fostering the **innovation potential** of Research Infrastructures, in **complementarity** with the horizontal activities supported under Call H2020-INFRASUPP-2014/2015 (in particular topics INFRASUPP-3-2014 and INFRASUPP-4-2015). Activities should contribute to a **faster adoption of best practices** and foster the use of **open standards** and **interoperability** in data and computing services. When addressing common or interoperable data services, proposals should encompass the definition of metadata, ontologies and identifiers as well as models (e.g. open web services) to process semantics at machine level.	This will include the definition of domain specific data policies (e.g. acquisition, deposit, curation, preservation, access, sharing and re-use), addressing any **legislative** or **interoperability** issues which affect data handling across geographical and discipline borders, as well as the development of appropriate tools for depositing, curating and analysing data. Proposals may address the development of **domain specific skills** for data stewardships and the specific training of Research Infrastructure staff. Activities should contribute to a **faster adoption of best practices** and foster the use of **open standards** and **interoperability** in data and computing services.

Table 5 – INFRAIA call text[32]

Integrating and opening existing national and regional Research Infrastructures of European interest	**WP 2014-2015** **EUR 140 million**	**WP 2016-2017** **EUR 242 million**	**WP 2018-2020**
Scope	Integrating Activities (IAs) should give due attention to any related initiatives **internationally** (i.e. outside the EU), foster the use and deployment of standards, carry out research on impacts of the involved Research Infrastructures (direct and indirect, on social, environmental and economic levels) as well as of the project itself. Integrating Activities should also organise the efficient **curation**, **preservation** and **provision of access to the data** collected or produced under the project, defining a data management plan. Data management, interoperability (definition of metadata and ontologies) as well as advanced data and computing services should be addressed where relevant.	As per 2014-2015 but now includes a reference to the **Open Research Data Pilot (ORDP)** and includes expectation that projects should define a **data management plan even when they opt out of the ORDP.** The call text does no longer recommends a dedicated work package for **innovation**. Call now specifies that Integrating Activities are expected to reflect on **sustainability**.	As per 2016-2017 but scope now states that proposals should adopt the guidelines and principles of the **European Charter for Access to Research Infrastructures**[32]. Call text now states that in addition to reflecting on sustainability, proposals should ensure **complementarity** and **coherence** with the existing European infrastructures landscape. Call text now states that proposals should include clear **indicators** allowing the assessment of the progress towards the general and specific objectives, other than the access provision.

[32] European Charter for Access to Research Infrastructures, 2016
https://ec.europa.eu/research/infrastructures/pdf/2016_charterforaccessto-ris.pdf

	Integrating Activities in particular should contribute to fostering the potential for innovation, including social innovation, of Research Infrastructures by reinforcing the partnership with industry, through e.g. transfer of knowledge and other dissemination activities, activities to **promote the use of Research Infrastructures** by industrial researchers, involvement of industrial associations in consortia or in advisory bodies. A **specific work package on innovation** is therefore recommended in all Integrating Activity proposals. Integrating Activities are expected to duly take into account all relevant ESFRI Research Infrastructures to exploit **synergies** and to ensure that rationally designed, comprehensive and coherent overall concepts for European Infrastructures are being pursued		

ABBREVIATIONS

Associate Country (AC)

Conceptual Design Report (CDR)

Cost Book (CB)

Design Studies (DS)

Directorate-General for Research and Innovation (DG RTD)

Distributed Research Infrastructure (DRI)

European Commission (EC)

European Commission's DG Research and Innovation (DG RTD)

European Intergovernmental Research Organisation forum (EIROforum)

European Open Science Cloud (EOSC)

European Regional Development Funds (ERDF)

European Research Area (ERA)

European Research Infrastructure Consortium (ERIC)

European Strategy Forum on Research Infrastructures (ESFRI)

European Union (EU)

Framework Programme (FP)

Global Research Infrastructure (GRI)

Group of Senior Officials (GSO)

Health & Food (H&F)

High-Level Assessment Expert Group (AEG)

High-Level Expert Group (HLEG)

Horizon 2020 (H2020)

Horizon Europe (HE)

Implementation Group (IG)

Integrated Infrastructures Initiatives (I3)

Integrating Activity (IA)

Joint Research Activities (JRA)

Joint Research Centre (JRC)

Long-Term Sustainability (LTS)

Member State (MS)

Networking activity (NA)

Open Research Data Pilot (ORDP)

Physical Science & Engineering (PSE)

Preparatory Phase (PP)

Readiness Level (RL)

Research and Innovation Actions (RIA)

Research Data Alliance (RDA)

Research Infrastructure (RI)

Single-Sited Research Infrastructures (SRI)

Social & Cultural Innovation (SCI)

Staff Working Document (SWD)

Strategy Working Group (SWG)

Support Action (SA)

Technical Design Report (TDR)

Technology Readiness Level (TRL)

Transnational Access (TA)

Value-Added Taxes (VAT)

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KI-02-20-397-EN-N

EU support to Research Infrastructures has contributed to transforming the way science is done in Europe, establishing open, merit-based access to world class infrastructures across Member and Associated States.
Research Infrastructures are essential providers of services for researchers, contributing to scientific excellence and to European shared objectives of equal opportunity in science, innovation and competitiveness.
This report by an independent group of experts carries out a thorough assessment of EU support to the preparatory phase of pan-European Research Infrastructures, looking at the evolution of funding instruments and formulating recommendations for ensuring the long-term sustainability of the European Research Infrastructure system.

Studies and reports

Publications Office
of the European Union

doi:10.2777/3423
ISBN 978-92-76-19272-5