



EIROforum discussion paper: Long-term sustainability of Research Infrastructures

Executive Summary

This paper tackles the issues of long-term sustainability of Research Infrastructures (RIs), which was launched in the European arena in 2014. The paper should be considered as a contribution to this discussion led by the European Commission, and involving other stakeholders. Having long-standing experience in managing large-scale European RIs, EIROforum wishes to contribute to this discussion. The paper does not aim at being exhaustive but emphasizes the main elements that EIROforum believes constitute and define the long-term sustainability of RIs which have a European dimension and involve the joint effort of a number of member states. In this respect, EIROforum has identified five main criteria that enable RIs to be sustainable in the long term and can provide guidance for additional funding commitments, namely:

- 1) Relevance of an RI to its scientific community and the ability to generate scientific excellence;**
- 2) Sustainable governance model and legal framework;**
- 3) Sustainable funding model;**
- 4) Ability to attract scientific talent and build a critical mass of scientific expertise; and**
- 5) Socio-economic impact.**

EIROforum remains available to explain its position in more detail, if required, in dedicated follow-up meetings.

Introduction

EIROforum brings together eight European intergovernmental Research Infrastructures (RIs). The organisations - CERN, EMBL, ESA, ESO, ESRF, EUROfusion, European XFEL, and ILL - have been established to provide the infrastructure required to perform state-of-the-art research in their respective fields. Their success in enabling scientific excellence and breakthroughs, as well as supporting scientific excellence of users, has been closely related to the fact that the EIROforum organisations operate infrastructures that are sustainable in the long-term, some of them existing for 60 years.

EIROforum is closely following the discussion launched in 2014 on the sustainability of RIs at different high-level European meetings, such as the Informal Competitiveness EU Council of Ministers (July 22, Milan), the conference “Evolving landscape of RIs in Europe” organised by the Italian EU Presidency (September 2014, Trieste), as well as in documents prepared by the Italian EU Presidency, ESFRI, and the European Commission. These discussions have so far brought about a growing recognition that large-scale RIs can only be successful if they are sustained in the long-term. **Having a long-standing partnership with the European Commission, which was formally inaugurated with a Statement of Intent¹, EIROforum is hereby presenting its experience of and views on the long-term sustainability of RIs.**

EIROforum has identified five criteria described below to be key in ensuring that RIs are sustainable in the long term.

1) Relevance of an RI to its scientific community and the ability to generate scientific excellence

The *raison d'être* of every RI is to serve the needs of a broad scientific community where individual parties need to share know-how and resources to enable scientific research that is impossible without confederation. Thus, it is essential that an RI establishes its scientific programme with its user community to ensure it is at the forefront of its scientific field.

Striving for excellence is an inherent characteristic of science and scientific communities, regardless of the field in which they operate. Excellence in research often requires state-of-the-art instrumentation and infrastructures. RIs therefore need efficient operations, continuous maintenance and timely upgrades of instrumentation and/or operational modes in order to ensure that the facilities correspond to the present and future requirements of their communities. The involvement and input of independent international external scientific and technical advisory committees is an efficient means of ensuring long-term leadership.

In some cases the needs of the scientific community and breakthroughs in technological development surpass the capacity or expertise of existing RIs. This may lead to the establishment of a new RI. Before establishing a new RI, it is essential to clearly define its added value to the scientific community and its complementarity relative to already established RIs in order to avoid overlap and duplication of investments. The question of phasing out an RI that cannot be further upgraded must also be faced in a timely manner. Having an appropriate phasing-out strategy in place ensures that – once an RI has concluded its life cycle – the funding needed for its operation can, where appropriate, be rechanneled towards other, emerging RIs.

While acknowledging that every RI needs to enable scientific excellence, larger, pan-European RIs in some cases enable major scientific breakthroughs simply due to the larger mass of instrumentation,

¹ EIROforum and the European Commission signed their first Statement of Intent (Sol) in 2003. The partnership was renewed in 2010. The 2010 Sol foresees cooperation, inter alia, in the following areas: research programming, training and mobility of researchers, research infrastructures, intellectual property rights and international cooperation in research.

staff and other available resources, which smaller, i.e. national, RIs do not have. In fact, all of the EIROs were created following the recognition of their respective scientific communities that the needs of the relevant research domain could not be fully satisfied nationally but required a cross-border effort involving resource pooling, risk sharing and federation of expertise. Nevertheless, it is important to stress the role of national infrastructures in supporting national communities of researchers and often offering the first contact with research to young talent. Additionally, they often provide first-class scientific output and important input to pan-European infrastructures and thereby significantly contribute to scientific endeavor.

Example 1: Keeping up with a scientific demand - ESRF Upgrade Programme: For more than two decades ESRF has been one of the world's leading synchrotron light sources when measured in numbers of, for example, users and in scientific output. Worldwide the demand for high-brilliance X-ray beams has been growing and consequently four synchrotrons were inaugurated in Europe alone between 2006-2010. At the ESRF, the user communities have been specifically demanding smaller nanosized beams with higher brilliance, improved facilities and instrumentation on the beamlines and, not least, more beam-time, or a higher throughput of experiments. The ESRF Upgrade Programme (2009-2022) is serving this demand with the additional objective to maintain the ESRF's role as the leading European provider of hard synchrotron radiation X-ray light in the forthcoming two decades.

Example 2: Scientific need for an extra peak power light source - building of European XFEL The European XFEL will generate ultrashort X-ray flashes—27 000 times per second and with a unique peak brilliance that is a billion times higher than that of the best X-ray synchrotron radiation sources. The ultrashort and extremely brilliant X-ray flashes will enable researchers to observe, amongst other things, the dynamic processes such as changes of the atomic structure of molecules during a chemical or biological reaction. These features will open up completely new research possibilities and complement the scientific offering of actual and future state of the art synchrotron radiation light sources. European XFEL will start operation in 2017.

2) Sustainable governance model and legal framework

While much science is carried out on the basis of individual projects in every RI, the organizational, governance and legal frameworks of the RI are crucial to ensure coherence and sustainability of the research effort to enable full exploitation of research results on long time-scales.

The continuity and steady progress of intergovernmental RIs is guaranteed through their founding treaties, which offer a regulatory framework that is both flexible and reliable. All EIROforum organizations are based on arrangements amongst member states, such as intergovernmental conventions or treaties, although they have opted for different legal models as regards their implementation. These vary from an international organization, a non-profit company model established under national law or a joint undertaking and a multi-party agreement. These legal models ensure that the administrative workload within a particular RI is minimized. In the constantly evolving and always competitive global research environment the organizational framework of RIs needs to support streamlined decision-making processes throughout the planning and operations period. In particular, a decision making process able to identify the needs and ambitions of all member states/funders, and to respond rapidly with adequate programmes and/or projects, is a prerequisite to their continued relevance. The governance and legal frameworks must ensure that the implementation of the programmes, in particular the organisation of the industrial and scientific consortia that will

support the development of the RI, are adequate to the member states/funders capacities and ambitions and, when relevant, national regulations.

For pan-European RIs, the host country - or in distributed RIs the host countries - play a vital role in ensuring the smooth establishment and functioning of the RI. The relationship between the RI and the host country(ies) is often regulated in a separate legal document. Host countries should support the RI by facilitating or encouraging its future development through, among other actions, providing attractive conditions for its operation, additional financial means in recognition of benefits that are brought nationally and programmes to attract staff from the member states/funders.²

Example 1: Non-profit private company and intergovernmental convention – ILL: To construct and operate the ILL, its international partners agreed to found an independent research organization, i.e. a non-profit private company governed by French law – *société civile* – named the *Institut Max von Laue- Paul Langevin*. The company has its own workforce. The ILL has currently 15 member countries. The Associates participate on the basis of an intergovernmental convention established in 1973 and currently valid at least until 2023, and which is usually renewed for ten-year terms. The Scientific Members participate through bilateral contracts with the ILL, usually of 5-year duration. The ILL Convention lays the basis for scientific collaboration and stipulates the responsibilities of the associates with regard to the decommissioning of the ILL as an RI. User access is organized through two rounds of calls for proposals per year. The selection of projects is decided by ILL management following the advice of the Subcommittees of the Scientific Council, based on scientific merit. The ESRF was constituted following the model of the ILL.

Example 2: Intergovernmental Convention of ESO: ESO is based on an intergovernmental convention, which ensures its long-term sustainability. The ESO Convention does not require renewal, but member states have the legal possibility to withdraw after 10 years of membership. The Convention prescribes active participation of scientists in its governing body, thereby providing close links to its user community and ensuring continued scientific relevance, together with representatives of its member state governments.

3) Sustainable funding model

In order to adequately support an RI, decision-makers need to ensure the necessary ongoing investments for optimal operation, so that the RI can continuously contribute to building the pool of knowledge and talent required for the future. This is often reflected in regular discussion between the RI and its funding partners of the necessary operational budget. While “one-off” project funding can be used to address a specific research question, or to emphasize priority areas for investment in research, it is not an adequate mechanism to support the operation of a large-scale RI and, through this, to build and maintain basic research capability in the long term.

An RI having in place a sustainable funding model may in many cases already achieve its long term sustainability. However, in some cases having a sustainable funding may not be a sufficient factor for success; an RI may face difficulties in attracting scientific talent or operate in a field losing its scientific

² For more information please see EIROforum paper “Establishing new Research Infrastructures in Europe” (http://www.eiroforum.org/downloads/201003_policy_paper.pdf)

relevance, which would eventually affect its ability to generate scientific excellence. Thus it is important to consider sustainable funding in the context of other criteria identified in this paper.

Considering therefore that all RIs need adequate resources to stay at the front-line – both human and capital resources – these facilities can only be successful if they operate with a favorable long-term perspective, i.e. one that enables long-term financial planning with appropriate guarantees by the funding countries or other shareholders. This implies the existence of regulations ensuring a long-term commitment from the funders. Crucially, the long-term financial planning must cover operations cost, including the necessary maintenance and instrumentation upgrade costs. The long-term nature of basic research calls for long-term security for the supporting RIs. A common characteristic of the EIROs is that they are able to link long-term funding with clearly defined scientific objectives/programmes. In addition to the strong scientific case, transparent evaluation and reporting arrangements facilitate funding decisions.

Investments in large-scale RIs are driven by the vision of progress in a particular scientific field. However, many countries anticipate that their financial contributions to such RIs will bring a rapid return on investment. Some RIs are in fact from the very beginning (partially) established on the principle of return as this was deemed to serve best their purpose or the needs of their scientific communities or member states. Periods of economic difficulty for the member states often lead to demands for more return on investment. While enabling returns is a necessity, and part of the structure for some RIs, it is nevertheless important to stress that the overarching goal of every RI – and the one that should guide investment decisions - is the overall advancement of the science enabled by the RI.

Example 1: Approval of EMBL's 5-year indicative scheme by its member states: The EMBL Council, composed of all member states of the Laboratory, must unanimously approve the indicative scheme for the realisation of the EMBL programme for a period of 5 years. The indicative scheme determines the maximum funding level that may be committed or spent during the duration of that scheme. It is important to note that the scheme is “indicative” thus not strictly tied to specific research outputs, but instead offers certain flexibility so funds can be distributed to support newly arising opportunities if necessary. Member states contribute to the budget based on a formula involving Net National Income (NNI). The investment of the member states is subject to audit. Project-based funding, which may be acquired during a particular indicative scheme, is not considered during long-term planning for the Laboratory, but comes in addition to the secured membership contributions. This competitive project funding allows EMBL to support investigator-led research, which is complementary to but does not substitute its mission-led funding.

Example 2: Long term financial planning at ESO: ESO is financed primarily by contributions from member states, which are proportional to their NNI and made every year according to a scale laid down by the Council in accordance with the provisions of the ESO Convention. In determining the total amount of such contributions, account is taken of income available to ESO from other sources and of the requirements to guarantee the proper financing of the Organisation. This model enables long-term financial planning, which is crucial for developing and operating major RIs, which often entail construction periods of 10-20 years followed by an operational period of 25-50 years. It also provides a stable vehicle for expanding the original programme with additional infrastructures building on the acquired know-how and existing infrastructures. For ESO these include the Very Large Telescope on Paranal, participation in the global ALMA project and, recently, the construction of the European Extremely Large Telescope.

4) Ability to attract scientific talent and build a critical mass of scientific expertise

The ability of an RI to attract scientific talent and to build a critical mass of scientific expertise is closely related to the potential of the RI to enable cutting edge science. Sustainable RIs encourage international mobility and attract talent from all over the globe to their sites. This brings diversity of ideas, which in turn further builds up scientific excellence and allows the RI to maintain high standards of research.

Critical mass of scientific talent is based on outstanding scientific opportunity but can be built up through mechanisms such as attractive employment conditions, transparent recruitment practices, openness to diversity, and adaptable PhD and post-doctoral curricula. Additionally, RIs can finance or co-finance studentships and doctoral and postdoctoral fellows. In order to preserve links to national educational systems, doctoral and post-doctoral programmes can be designed together with universities, thus enabling young researchers to acquire hands-on experience at the RI while maintaining links to their home universities. Developing and managing new instrumentation also generates the need to train technologically skilled personnel and ensure their mobility. It should be noted that at the moment RIs in Europe are very successful in attracting the best scientific talents but face difficulties in attracting experts in instrumentation and engineers.

RIs can build up their pool of scientific talent by enabling inter-institutional and trans-national mobility at all career levels³ but with particular focus on young researchers. This can be achieved through short-term visiting exchanges (from lab to lab), organization of scientific events or dedicated workshops, as well as targeted training opportunities. RIs can consider innovative mechanisms, such as engaging in partnerships with industry, in order to facilitate participation of talented researchers and engineers from less developed regions in their training events.

For all EIROforum organizations, training the next generation of researchers and engineers is part of their core mission. EIROs have in place training programmes for doctoral and postdoctoral fellows as well as other young researchers and scientific and technical staff, which encourage mobility and exchange of knowledge.

Example 1: Training the next generation of scientists and engineers at ESA: ESA offers a variety of options for training of young researchers and engineers at different stages of their carrier: 1. 'Young Graduate Trainee' programme enables master graduates to take on a responsible role in supporting a project, and benefit from the expertise of an ESA mentor for one year. 2. 'Network/Partnering initiatives' between ESA and universities in member states enable young researchers to obtain a doctorate. 3. 'Postdoctoral Research Fellowship programme' aims to offer young scientists and engineers with a doctorate the possibility of carrying out research in a variety of disciplines related to space science, space applications or space technology for two years.

³ In 2011 EIROforum and the European Association of National Research Facilities (ERF) suggested a mechanism, which aimed at helping new RIs by providing experienced and senior staff for a limited period of time filling the gap in highly qualified leadership positions, while replacing staff in the existing infrastructure with young researchers, thus also providing new training opportunities. For more details please see: http://www.eiroforum.org/downloads/201111_mobility_proposal.pdf

Example 2: Training the next generation of scientists and engineers at CERN: Training of young scientists and engineers is one of the main missions of CERN. The organisation has a variety of training programmes for undergraduate and graduate students, as well as for researchers in the initial stages of their careers in different fields of science and technology. Currently, CERN has over 600 Fellows with engineering or scientific MSc or PhD degrees, 180 doctoral students working on their PhDs in collaboration with their home universities, over 200 technical students who stay up to 12 months at CERN during their undergraduate studies, and also some 30 administrative students who gain useful trainee experience in fields such as human resources, finance, purchasing and science communication.

5) Socio-economic impact

Science performed by sustainable RIs can drive major socio-economic changes and play a crucial role in the development of our society, which can be recognized on different levels.

Firstly, one can distinguish between the long-term socio-economic impact to society as a whole or certain aspects of society. The invention of the World Wide Web at CERN may be the most prominent recent example of a general benefit to the whole of society. Another example is investigator-driven research in quantum physics in the early 20th century, which ultimately resulted in computers and lasers. A possible future major impact may lie in electricity generation by means of thermo-nuclear fusion. RIs can also have a socio-economic impact through developing instrumentation or conducting basic research with significant applicability for the future well-being of citizens. Examples of the latter are research in basic molecular biology that translates into medicine, food safety, etc., and the significant applicability of research in the field of material sciences.

In this respect, while the vast majority of RIs perform curiosity-driven fundamental research, it is nevertheless important that they also engage in technology development and transfer and link to industry.⁴ These activities are driven by the need of RIs to push the technology frontiers in their respective field of science, which often has significant innovation potential. Many RIs have thus organized their own technology transfer initiatives in order to facilitate and accelerate the transfer of innovative technology from laboratories to industry. It is noticeable that links between RIs and industries have much improved in the past decade.

Secondly, a very important aspect is the socio-economic effect of RIs on their immediate local and regional environment. By attracting hi-tech companies and specialized facilities, educational establishments, and offering new employment possibilities, RIs create an 'innovation biotope' in their regions. The most obvious factor is the favorable economic return to the local region and the host country of an RI, which benefits directly from spending, for example, on supplies and services, local employment opportunities, and salaries in the local region. However, the impact of the presence of an RI goes beyond this in raising the international visibility of the region in which it is situated.

⁴ For more details please see EIROforum position paper on scientific instrumentation: http://www.eiroforum.org/downloads/20121101_position-paper-instrumentation.pdf

Finally, the dissemination of knowledge and raising the visibility of and awareness for science in the local environment and at the global level is another socio-economic aspect of RI-performed research. This contributes to increasing the science-awareness in citizens, who are key to a knowledge-based economy in a democratic society. Stimulating interest in science also supports the creation of a scientific talent base in society.

In the context of sustainability it is important that the decision-makers and funding bodies are made aware of and recognize the importance and potential of the diverse socio-economic impacts of RIs at both local and global scales.

Example 1: A multitude of innovations and research breakthroughs with wide socio-economic impacts at CERN and its outreach activities: CERN is a major engineering and technology centre and many innovative technologies developed at CERN for particle physics find numerous applications in other domains. The most famous example is the invention of the World Wide Web in 1989. Other breakthrough innovations with major impact on society include the development of accelerators and detectors for use in medical applications, such as hadron therapy for cancer treatment, PET scanners and novel medical imaging devices. CERN's impact on society also builds on intensive education and outreach activities. CERN hosts each year around 1000 teachers that participate in dedicated training programmes with the purpose of inspiring their pupils to study physics and engineering. Each year more than 100,000 people come to CERN to visit its exhibitions and take part in guided tours to some of the accelerator and experimental areas.

Example 2: Local impact of ESRF, EMBL and ILL in Grenoble: The ESRF, ILL and the EMBL Grenoble Outstation are situated on the European Photon & Neutron (EPN) Science Campus in Grenoble, along with the French Institute of Structural Biology. The three international institutes have clustered with world-renowned national French institutes (CNRS, CEA, GEM, G-INP and Université J. Fourier) to create the *Grenoble Innovation for Advanced New Technologies* (GIANT) Alliance with the aim to increase the international visibility and attractiveness of the Grenoble site. In return, the international RIs greatly contribute to the excellence of the site: experimental methods added to the existing palette, new research streams, access of many foreign visitors and users. Furthermore, common initiatives, seminars and workshops held on the site induce significant knowledge spill over to the local environment. This results in self-reinforced feedback loops fuelling the international visibility and attractiveness of the Grenoble site. The economic return to the region generated by the presence of these RIs is very favourable, a fact acknowledged by the French local government with the allocation of exceptional funding to the ESRF and the ILL for the improvement of their facilities and the EPN Science Campus over the period of 2007-2020.

Example 3: Towards unprecedented socio-economic impact addressing grand societal challenges "Secure, clean and efficient energy": Working towards fusion electricity at EUROfusion: Under the umbrella of EUROfusion, 29 European fusion laboratories coordinate their research towards the common target of harnessing fusion processes, which will bring nearly unlimited, safe and friendly energy. Harnessing efforts in European fusion research is thus expected to have a major European-wide socio-economic impact in the future: EUROfusion works towards the goal of having a demonstration power plant feeding electricity to the grid in 2050.

EIROforum

EIROforum was established in 2002 and is a partnership between Europe's intergovernmental research organisations operating large scale Research Infrastructures, and representing different fields of science (high energy physics, plasma physics, biology, space technology and exploration, astronomy astrophysics, science-ray and neutron science for biology, chemistry, condensed matter physics, material and environmental sciences and medicine). Today, it has eight member organizations, all treaty-based and supported by countries, many of which, but not exclusively, are member states of the EU. The partner organisations are world-leaders within their particular science field and there is increased interest by non-European countries to join these organisations.

CERN	European Organisation for Nuclear Research
EMBL	European Molecular Biology Laboratory
ESA	European Space Agency
ESO	European Organisation for Astronomical Research in the Southern Hemisphere
ESRF	European Synchrotron Radiation Facility
EUROfusion	European Consortium for the Development of Fusion Energy
European XFEL	European X-Ray Free-Electron Laser Facility
ILL	Institut Laue-Langevin