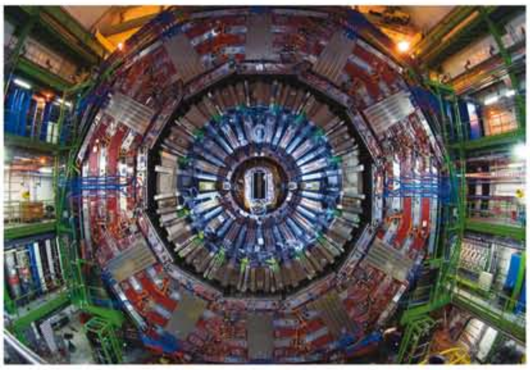
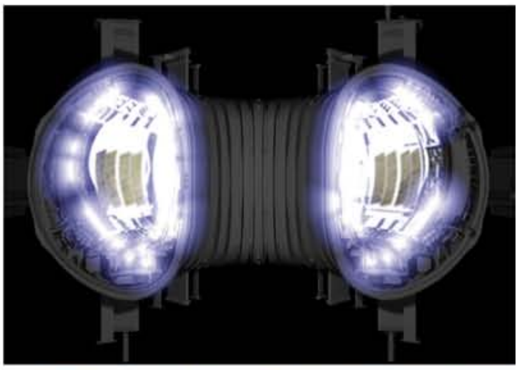
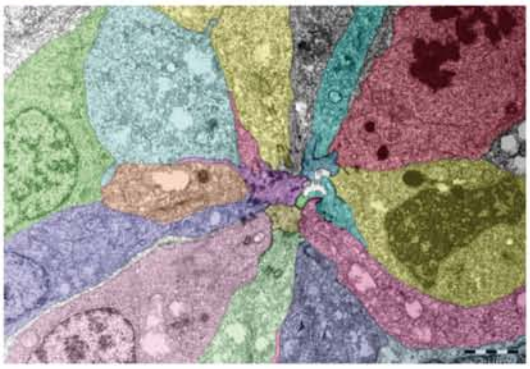
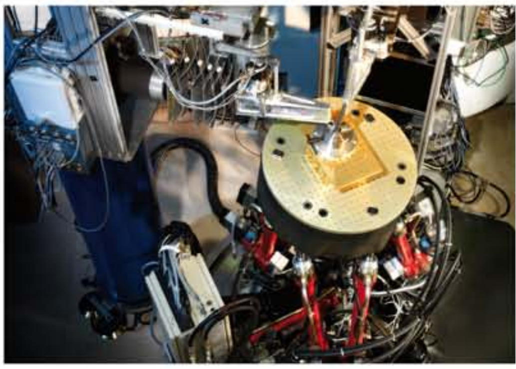
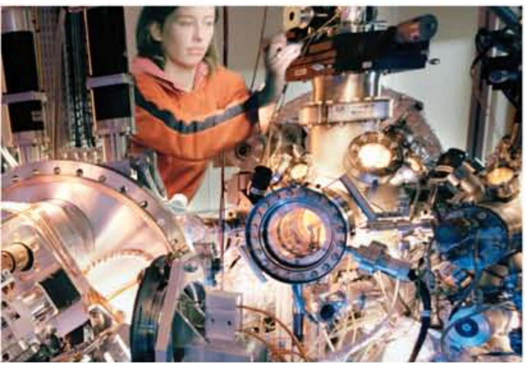
Europe's Intergovernmental Research Organisations
– a Key Pillar of the ERA

EIROforum

Establishing New Research Infrastructures in Europe – The EIROforum Experience

March 2010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This document addresses the challenges that must be faced in the establishment of new research infrastructures in Europe. Key challenges are identified by the seven member organisations of EIROforum. Their collective experience in creating and sustaining research infrastructures is presented and illustrated by concrete examples.

Executive Summary

- Major research infrastructures are essential for Europe's knowledge-based economy and sustainable competitiveness. They provide services to the scientific community and are focus points for research, training and innovation.
- Seven intergovernmental organisations representing the largest European research infrastructures in particle physics, molecular biology, astronomy, space science and technology, human space flight, materials science and fusion energy science and technology have formed the EIROforum partnership.
- The ESFRI process facilitates the construction of new infrastructures and major upgrades of existing facilities in Europe. ESFRI has published a Roadmap with 44 projects currently in different stages of preparation and implementation.
- EIROforum has identified the main challenges encountered by research infrastructure projects and can provide many examples from the collective experience and practice of its members to illustrate how these can be addressed:
    - Consortium creation
    - Legal instruments
    - Convention and governance
    - Financial sustainability and stability
    - Return on investment
    - Site selection
    - Technical studies and design
    - User access and data management
    - Knowledge sharing
    - Training
    - E-infrastructures
- Constructing and operating large research infrastructures is complicated and there is no single ready-made solution that can be applied to all new infrastructures. The EIROforum's collective experience will provide important insights into possible solutions.
- Creating new European Research Infrastructures and achieving world-class excellence requires concerted and sustained efforts by various stakeholders. The EIROforum members have several decades of expertise in the construction and successful operation of large international research facilities, and would now like to make their experience available for the benefit of all.

1. Introduction

Pan-European research at the cutting edge is driven by world-class research infrastructures (RIs). They help to support Europe's competitiveness in scientific research, underpin the knowledge-based economy, and are essential to meet current and future challenges that face Europe and the world. These considerations led to the establishment of the seven European Intergovernmental Research Organisations (EIROs) that constitute the current members of EIROforum. The strong support and long-term commitment of their member states enabled the EIROs to become firmly established as world leaders on the basis of scientific and technical excellence and forward-looking governance structures. Each EIRO predicated its creation with a mature science case, a credible technical basis, strong support from the scientific community that resulted in a productive dialogue between scientists and political decision-makers, and the provision of a stable financial foundation. These are all essential prerequisites for establishing and maintaining successful RIs in the long-term.

The recognition in the EU member states and the European Commission of the pressing need to strengthen European science and research by establishing new RIs of pan-European interest has led to the generation of strong political support for these undertakings and considerable activity throughout the research community. The creation of the European Strategy Forum on Research Infrastructures (ESFRI) and the publication of the ESFRI Roadmap in 2006 – and its update in 2008 – highlight the long-term need to strengthen European science and research by establishing new RIs of pan-European significance and provide momentum towards the realisation of this crucial goal.

Under the ESFRI process more than 40 projects from diverse scientific fields, and at different stages of maturity, were selected with the support of the scientific communities and policy stakeholders of the EU member states and associated states. These projects are expected to result in the creation of a significant number of new RIs in the next 5 to 10 years.

The EIROs have decades of collective experience in the conception, creation, establishment, maintenance and renewal of major international RIs and they are already coordinating new RI projects themselves. They also provide advice and support to several international projects and organisations in key technical and non-scientific fields, such as management, procurement, and relations with industry. The EIROs offer to share their collective knowledge, expertise and established models of good practice with evolving new RIs to support and help these in the process of becoming world-class facilities for scientific research.

This document identifies and addresses the challenges that new European RIs will face in becoming established. EIROforum's collective experience in creating and sustaining RIs is presented and illustrated in this document by concrete and carefully selected examples. The document points out stumbling blocks and highlights areas that could be improved by policy makers, governments and funding agencies and particularly creates awareness for the financial requirements for RIs in the future.

Many stakeholders in Europe will have to work together to bring the ESFRI process to fruition and their commitment and determination to combine resources and know-how will be needed to build and operate world-class RIs. The EIROs are ready and willing to play their part in this, the next major step in the creation of a European Research Area.

2. European research infrastructures

World-class RIs drive scientific excellence and form a major constituent of the European Research Area. They are therefore pivotal in developing and maintaining Europe's competitiveness in scientific research and innovation. They enable European countries to:

- Establish and retain global scientific leadership;
- Set scientific and, in some cases, political agendas in research;
- Act as competent and strong partners in global research;
- Provide their scientific communities with access to the most advanced research facilities;
- Disseminate expertise in cutting-edge technologies throughout the member states through user training;
- Generate added value collectively, beyond the capacity of any single country;
- Stimulate industry and increase the socio-economic impact of science through the generation of new knowledge, novel technologies and advanced applications.

3. Vision, impact and longevity

During the post-war period, the intellectual and economic imperative to (re)establish European leadership in science drove a number of European countries to pool resources to establish joint RIs and facilities that few countries, if any, could individually afford.

The seven current members of EIROforum were created between the 1950s and 1980s with a clear vision for the future impact of such RIs. The strong support and long-term commitment of their member states enabled the EIROs to become firmly established as world leaders in the life sciences, physics, astronomy, space science and technology, human space flight, materials science and fusion energy science and technology. Their experience and success as European RIs has created trust with their member states, and several new projects or major upgrades of their facilities were included on the ESFRI Roadmap.[1]

The reasons for the impact and longevity of the EIROs are three-fold:

Excellent science

- They provide world-class centres of excellence, attracting the best scientists and researchers globally, to enable the production of outstanding science.
- They engage closely with the scientific and industrial innovation communities of their member states, creating synergies to leverage expertise and capacity beyond the infrastructure alone. They connect Europe, via their scientific cooperation programmes, to the rest of the world.

[1] CERN: *LHC upgrade*; EMBL: *ELIXIR, EURO-BioImaging*; ESO: *ELT*; ESRF: *Upgrade*; ILL: *20-20 Upgrade*. The Preparatory Phase of the projects on the ESFRI Roadmaps is co-funded by the FP7 "Capacities" Programme.

- Their scientific and technology programmes, formulated in close consultation with their research communities, contribute significantly to the structuring of European research and innovation. They effectively implemented the European Research Area concept within their respective scientific disciplines long before it was formally advocated.

Sound governance

- They operate under the aegis of sound intergovernmental agreements, each of which reflects specific organisational needs and provides for long-term operational and financial stability.
- They have proven organisational and management models that ensure the sound establishment, operation and upgrading of the large-scale facilities they design and operate on behalf of their member states.

Public responsibility

- They benefit Europe's social and economic interests through innovation, knowledge sharing and technology transfer, cooperation with industry, and the development of new electronic infrastructures.
- They contribute to the future of science by educating and training young scientists and engineers, disseminating scientific information to the wider community, establishing networks with the scientists and actively engaging in outreach activities.

These principles provide a framework against which new European RIs can define their requirements and goals and measure their achievements.

4. Confronting the challenges

Each EIRO predicated its creation with a mature science case, a credible technical basis, and strong support from the scientific community. Each maintains a dialogue between scientists and political decision-makers, and each has a stable legal and financial foundation. These characteristics all address important requirements that are needed to establish, maintain and expand successful RIs in the long-term.

The collective EIROforum experience shows that certain fundamental challenges must be met to ensure the success of a new RI.

4.1 Consortium creation

The drive to create a new multi-stakeholder RI arises from the scientific aspiration and the technical ability to achieve collectively that which cannot be achieved individually. Action follows when the funding capacity of the interested parties reaches a critical mass.

The coherence of events and actions is crucial in the process of establishing and ensuring the future success of an RI. Beyond the initial catalyst of critical mass, momentum needs to be sustained if objectives are to be met. This means effort by the project champions, not only to maintain interest but also to bring actions and actors into alignment.

The establishment of an RI usually needs a consortium of countries and/or organisations acting together, the size of which will depend on:

- the overall capital and operating costs required to establish and operate the RI;
- the availability of funders, and the resources they can bring;

- the nature of the nascent organisation;
- the relationship between the candidate consortium members.

Starting with a small consortium can be beneficial as agreement on the essentials of the organisation can be reached quickly. Irrespective of the size of the initial consortium, provision for enlargement can be foreseen in the convention.

However, this should be weighed against the fact that a larger founding membership brings more support, funding and long-term commitment, which can off-set additional coordination and management overheads that might arise. The lead member(s) should be able to exert greater leverage on the formation of the RI.

ILL *was founded by France and Germany in 1967 and was joined by the UK six years later; it opened its Scientific Membership in 1987 and has a current subscription of 11 states.* ***ESO*** *followed a similar pattern starting with five member states, which has now expanded to 14.*

Other EIROs started with a larger nucleus followed by a steady increase: ***ESRF*** *from 12 to currently 19 members and scientific associates;* ***CERN*** *from 12 to 20;* ***EMBL*** *from 10 to 20;* ***ESA*** *from 10 to 18 plus three European cooperating states.*

EFDA-JET *provides yet another model. It started with the 13 members of the JET Joint Undertaking in 1978. The JET facilities are now being used collectively under EFDA by 26 associate members.*

4.2 Legal instruments

Each type of legal instrument lays down the terms and conditions under which an organisation may operate, and sets the parameters that define the way in which it may evolve. It is essential that the legal instrument enables a newly established RI to act according to its intentions.

Three types of instrument have been adopted by the EIROs. All have secured successful multi-party activities based on agreements between their member states. These instruments include:

- International organisation;
- Non-profit company model, established under national law;
- Joint Undertaking and multi-party agreement.

A new legal framework for a European Research Infrastructure Consortium (ERIC) was adopted by the Council of the European Union in June 2009,[2] which complements other legal forms that exist under national, international or Community law.

[2] COUNCIL REGULATION (EC) No 723/2009 of 25 June 2009

__CERN__, the first European scientific joint venture, was established with an international organisation agreement in 1954 and served as a model for __ESA__, which arose by a merger of the European Launcher Development Organisation and the European Space Research Organisation in 1975. __ESO__ and __EMBL__ were both established by international agreements made in 1962 and 1973. These EIROs adopted the same type of legal instrument and governance model.

__ILL__ was founded in 1967 through an inter-governmental convention stipulating the establishment of a non-profit company based on French law, as was __ESRF__ 21 years later.

__JET__ started as a Joint Undertaking in 1978 under the Treaty establishing the European Atomic Energy Community. In 1999, the use of the JET facilities came under a multi-party agreement, the European Fusion Development Agreement (EFDA).

4.3 Convention and governance

Governance covers the balance of powers within an entity, including the management structure – the basic hierarchical structure – and the relationship between the different organs of the entity. The rules of governance should be defined in a convention or a comparable founding document. A sound convention is paramount to good governance and management. It should have the capacity to adapt structure and policy in response to scientific developments and operational needs. It should be forward-looking, allow for flexible solutions, ensure that the interests of the members are kept in balance, and should encourage optimal operational efficiency. It should reflect the members' input and interests whilst serving the scientific and technical requirements of the facility. It should make clear and transparent the division of roles and responsibilities between management and the governing and advisory bodies.

The convention is the basis for all other important elements needed for the operation of the infrastructure: staff policy, access policy, IPR issues, data management, the definition and evaluation of research programmes, rules for introducing new members, the applicability of law and the conduct of external relation. It underpins the committee structure and determines the hierarchy of decision making so that rights and responsibilities are transparent. It deals with voting rights that have a direct influence on the balance of powers.

Governance and control of issues such as policy and finance is exercised by the members and associates represented on the main governing bodies of the organisation. In addition, provision for ad personam appointments to scientific committees ensures the protection and promotion of scientific excellence.

The __CERN__ Convention is a good example of a simple, forward-looking founding document. In use for more than 50 years, it has been subject to just one amendment in 1970.

The __ESO__ Convention was adapted from that of CERN as the constitution, financial basis and personnel regulations of the two organisations are similar. Under ESO's Convention, every member state is represented on the Council by two delegates (at least one of whom should be a scientist); each member state has an equal vote; and the financial contribution of each member state is proportional to their national income with an upper limit. These mechanisms avoid the excessive influence of any single member state.

__ILL__'s Convention and Statutes have been laid down for more than 40 years and provide clear guidelines for the governance of the institute.

The __ESRF__ Convention and Statutes provide clear guidelines for the governance of the laboratory, including the service to be provided to the scientific community.

The __ESA__ Convention that entered into force almost 30 years ago has provided a stable basis for the research and technological development activities performed at ESA.

4.4. Financial sustainability and stability

The financial stability of the EIROs derives from the long-term funding models laid down in their founding agreements. The two pillars are adequate funding and stability of funding, commensurate with the required long-term horizons of the EIROs. The nature of RIs means that they usually take from 5 to 20 years to become operational and they normally remain in operation for decades. Stable funding enables prudent and economically sound choices and long-term planning.

There are specific issues that need careful consideration during the life cycle of a major RI:

Construction: The staging of settlements for construction work needs to be carefully aligned with the scheduled payments from members and associates to avoid the cost of bridging loans. A site premium paid by the host country or countries is good practice and could be part of the convention.

Upgrades, refurbishments and decommissioning: These need to be planned from the beginning, to cover both financial and technical perspectives. Apart from maintaining premises and facilities in good order, the cost of retiring outdated equipment and instrumentation needs to be taken into account. Even though such funding may only become necessary at a later stage of development, the funders need to agree to this in advance with provisions made in the accounts and payment schedules.

Operation: The successful operation of the RI depends on financial stability. Apart from capital costs, plans need to be made – ideally at the stage of signing the convention – for the securing of funds to cover recurrent expenditure for both immediate and future activities.

In-kind contributions: These fail to compensate for membership fees and never cover the full costs of the infrastructure. They are therefore insufficient to operate a large infrastructure and impair operational flexibility. However, in the right circumstances, in-kind contributions can serve useful functions in enabling technical upgrades and broader international support for the RI.

At __ESRF__, the Convention distinguishes between the financing of the construction phase of the facility, which includes a site premium for the host country, and the operation phase, in which the financial contribution of its members is in line with their expected scientific use of the facility.

4.5 Return on investment

The funding members of an RI expect a return from their investment: access to state-of-the-art facilities, opportunities to participate in research projects and to train young scientists, and the delivery of excellent science. Industrial orders and contracts are also important benefits for the member states. Best value for money and lowest compliant bidder are the two most often used methods for awarding industrial procurement and service contracts. Whilst the value of the return may vary across the membership, particularly when intangible benefits such as national prestige are considered, and whilst the return might not be exactly equal in any one year, over time the proportion of benefit is expected to correspond roughly to the proportion of contribution to retain the commitment of the members.

The principle of juste retour, according to which the proportion of return to investment is rigorously applied, can prove onerous to implement and thus impede the efficient function of the RI. In addition, juste retour often increases costs as free competition is restricted and the opportunity to award contracts using other principles, such as "best value for money" or "lowest compliant bidder", is constrained. Nevertheless, juste retour can have positive aspects. Members can monitor industrial participation and take action at the national level to stimulate interest if necessary, for example capacity building in less developed regions that would not have received investments on the basis of scientific merit alone. Thus, juste retour can be acceptable and justified in specific circumstances.

CERN *does not apply a principle of juste retour, but rather fair return for industrial contracts. Once companies have been qualified technically, a shortlist is established taking into account the industrial return to the country and the contribution of the country of a given company. Furthermore, at contract adjudication, a realignment procedure is applied between offers from countries which over the last 4 years are in excess of return compared to the others.*

ESRF *and* ***ILL*** *provide good examples of several returns on investment principles. The juste retour principle is monitored on contracts and staff representation and is measured in science output. The return to the member states is monitored through a coefficient for scientific and purchases return and, under specific circumstances, corrective measures are applied. In addition, ESRF has used the "best value for money" principle since its creation.*

At ***ILL****, contracts are awarded according to "best value for money". ILL closely monitors the return to its associate member states and scientific members and aims to achieve juste retour. However, this is difficult because as a nuclear installation, ILL often has to place orders with specific national industries.*

EFDA-JET *does not apply the principle of juste retour. There is no link between funding and scientific participation in experiments, enhancements or fusion technology activities.*

ESA *applies the principle of juste retour according to which member states have a guaranteed return on investment.*

ESO *awards contracts to the bidder who submits the lowest compliant tender. The effectiveness of this policy depends on the quality of the tender documentation and ESO pays particular attention to that effect.*

4.6 Site selection

Selecting the site for a new RI is a complicated process, contingent on scientific, technical, social, economic, geographic, and political considerations. For example, an existing cluster of excellent research institutions may be favourable for some RIs, whereas the technical requirements of other new RIs may be met by only one or very few sites. The relative merits of a single or multi-site RI warrant appraisal: for example, separating scientific and administrative functions; locating facilities where there are already centres of excellence; and selecting a single site to cluster with a complementary pre-existing facility.

If there is an obvious scientific or technical case that dictates the primacy of a specific site the process of selection is straightforward. Otherwise, there is no pre-defined simple model for optimal site selection and the selection criteria, factors and decision process may be different for each RI. In cases where the site selection is critical, scientific considerations must form the basis of the decision. Site selection should ensure that optimal scientific and technical functionality is possible and that consideration is given to the long-term operation of the facility. The availability of land for future expansion, possible changes in site access (major infrastructure schemes), and the availability of a skilled labour force in the future, must all be taken into account. As well as RI maintenance and the provision for future upgrades, it is important that requirements for the decommissioning of facilities and exit strategies are considered from the outset.

Notwithstanding the above, host countries recognise the economic and other benefits of having an RI located on their territory. If financial incentives are offered, transparency in the decision making must be ensured. Any trade-off between optimum scientific productivity and other factors should be expressed and accepted by all stakeholders at the time the decision is made.

ESO *and* ***ESA*** *have operational sites distant from their headquarters to meet scientific and operational needs. For example, ESO deployed its telescopes in Chile both to exploit the superior climatic and atmospheric conditions and because of the possibility to see celestial objects that are of particular scientific interest. The ESA launch site is located in Kourou, French Guyana, to meet physical launch requirements mainly for commercial satellites.*

EMBL *was established as a multi-site infrastructure for scientific and technical reasons and to take advantage of existing centres of excellence for life science applications.*

CERN, ***ILL***, ***ESRF*** *and* ***EFDA-JET*** *all operate large single-site facilities. The Convention of CERN, signed in 1953, nevertheless foresees the possibility for the Organisation to have several laboratories on different sites.*

4.7 Technical studies and design

In-depth technical design studies and realistic project planning – including financial engineering and precise schedules – are crucially important for the successful realisation of a new RI. Detailed design studies might seem costly, but considering the overall construction and operational costs of the RI, including their longevity, they constitute a relatively minor, but essential, aspect of total investment and may result in substantial savings by preventing subsequent problems.

As most technical elements are manufactured through industrial orders, industry should be involved as early as possible to verify feasibility and ensure accurate costing.

Design studies should identify critical path items, high-risk technological and / or scheduling items and key decision points. They should provide guidelines for risk mitigation and alternative solutions, as well as refining cost estimates by highlighting areas of uncertainty. The design studies should also provide upgrade paths over the expected construction and operational lifetime of the RI, keeping in mind the need for maintaining the RI at the highest standard of scientific competitiveness.

*The development of **ESO**'s Very Large Telescope facility followed these principles and there is no doubt that the thorough work that went into the early phase of this project laid the foundations for the huge success of the facility. The preparation of ESO's Extremely Large Telescope (a project on the ESFRI Roadmap) is being handled the same way. A sequence of studies, involving industry whenever relevant, will underpin the final construction proposal expected towards the end of 2010. The total cost of these design studies will approach 5% of the overall construction and operation costs.*

4.8 User access and data management

A well-defined policy for user access is fundamental and should be clearly defined. In principle, RIs should offer open access to their facilities with peer review, ensuring priority is given to scientific excellence. However, where physical access is required to conduct experiments / observations members may elect to protect their "investment" in the RI and impose quotas and / or limit access for participants from non-member states. A fair balance between the promotion of science and juste retour to members needs to be found and agreed on and the legal requirements for data protection need to be taken into account.

A policy for data acquisition, management, and access is also a necessity, and protocols and procedures need to be built into the operation of the RI from the outset. These considerations should extend to defining and implementing standards of data quality, data cleaning, data storage and preservation, and the creation of meta-data.[3]

*The experimental programmes of **CERN** are open to participants from all member states and more than 40 non-member states from five continents, which have concluded Cooperation Agreements with the Organization. The data produced by the CERN experiments are made available to every institute that has participated in the experiment, regardless of its country of origin.*

*The allocation of telescope time at **ESO** is based on a peer review selection process and thus gives priority to scientific excellence. With one-year proprietary access rights for the proposing science team, all observational data are retained in the ESO Science Archives and are subsequently made available to the global scientific community.*

*At **ESA**, utilisation of the Scientific and Earth Observation satellites as well as the Columbus Laboratory on the ISS is granted according to peer review selection, for each programme, by its participating member states.*

[3] Meta-data can be text, voice, or images that describe or facilitate the use of the actual data.

Specific policies for industrial contracts are necessary for some organisations such as ***ESA****, in particular for the optional programmes. After an appropriate period (usually one year) all data become public through open-access archives.*

Others such as ***ESO*** *apply open access to data with time-limited privileged access for the scientists who have developed/obtained the data.*

ESRF*,* ***EMBL*** *and* ***ILL*** *allocate beam-time based purely on scientific excellence. All projects are subject to external peer review panels and users have an obligation to publish their results. Scientific juste retour is monitored at ESRF and ILL.*

EMBL*-EBI hosts the major data resources for biological data in open-access repositories.*

At ***EFDA-JET****, the use of the JET facilities, including access to all data, is open to all researchers in the European fusion community (that is, the laboratories of the EFDA associates) and individual researchers approved under an international collaboration agreement.*

4.9 Knowledge sharing

RIs are created and operated with the main purpose of conducting and enabling cutting-edge scientific and technological research, and generating new knowledge. There is a growing recognition that there is a moral, if not a legal, obligation to disseminate the information and knowledge generated as a result of publicly funded research.

Sharing knowledge through data repositories, open-access publications and technology transfer to industry are supported in different ways by the EIROforum organisations. The level and nature of the knowledge-sharing[4] activities are contingent on the science, its market and/or societal potential, and the availability and skills of personnel for exploitation of the knowledge. Models for knowledge sharing may include in-house dedicated units; wholly owned subsidiaries, for-profit companies returning profits (or a portion thereof) to the RI; or fully out-sourced.

The EIROs have developed different policies for the definition and management of intellectual property (IP) rights, which reflect the best practice recommended in the recently developed European Commission guidelines on knowledge-transfer activities.[5] In broad terms, these knowledge-sharing policies reflect the RI's mission, state the rights and responsibilities of the parties and specify how net returns are to be distributed. To be effective, IP policy needs to be communicated to all staff, and activities need to be monitored to ensure that the interests of all relevant parties, including those of the RI, are respected.

Knowledge sharing should receive consideration during the creation of an RI as it can have a major impact on the long-term health of the organisation. For example, a general policy to provide all results on technical developments and design without compensation to the member states may impose a difficult burden on the organisation. In the worst case scenario, the RI may be held responsible for faults caused when other organisations use and alter the designs.

[4] Knowledge sharing includes: dissemination of information, protection and exploitation of IP, relations with spin-out companies, licensing, consultancy, contract research with industry, collaborative research with the public sector or charities, business development, marketing, courses/workshops.

[5] COMMISSION Recommendation on the management of intellectual property in knowledge-transfer activities and Code of Practice for universities and other public research organisations, C(2008)1329, April 2009.

ESA *retains ownership of information, data and IP resulting from the contract when they have fully funded an activity. ESA has also adopted a specific Human Space Flight Data Policy. The ESA Technology Transfer Programme Office coordinates four Business Incubation Centres. ESA has also spun-out private companies such as EUTELSAT, one of the world's pre-eminent telecommunication satellite organisations, serving the interests of Europe's National Telecommunication Services plus other world-wide agents.*

EMBL *has been involved in more than 15 start-up companies, which were established using technology developed by EMBL scientists and the know-how of its technology transfer company EMBL Enterprise Management TT GmbH. EMBLEM, set up in 1999, currently manages a portfolio of ~300 individual patents, patent applications, copyrights, trademarks and utility models.*

ESRF *and* ***CERN*** *both have internal units with scientific, commercial, legal and financial expertise, that are responsible for technology transfer.*

At ***ILL****, the assistant to the Head of Administration is the initial contact point for matters involving IP with ultimate responsibility for ILL contracts – including IP ownership and usage – residing with the Director.*

4.10 Training

Training provision should to be planned from the very beginning of an RI to ensure resource requirements are met at the right time. The inherent cost of training provision, trainer fees, staff time away from paid activity and the cost of equipment usage, facilities and services, need to be accounted for in the budget.

Training is a public good and a private benefit. With each RI providing training, the recruitment pool is enriched and ultimately all stakeholders benefit from the availability of a trained and skilled research and technical labour force. Mobility of staff – between countries and institutes and across industrial and academic sectors – is an important element of the European Research Area. At the level of each RI the intellectual capital is increased, and individuals gain the opportunity to develop their careers.

Training provision for staff should include:

- Career development as part of the recruitment programme and embedded within each employment contract;
- Specialist training to cover on-site safety and security, and to ensure that staff have the necessary skills and knowledge;
- General training to improve "soft skills", in particular management and communication skills.

Training provision for external users could include:

- Courses and workshops ranging from events for undergraduates to involve and train future scientists to advanced training in cutting-edge science and technology being pursued at the RI;
- Training alongside education in "apprentice/master mode" for graduate students, working under the joint supervision of their "home" university and an RI scientist;

- Safety training for the user when on-site conducting research, plus specific training to ensure their optimal use of and benefit from the facility;
- Targeted education and outreach activities, through open days and the provision of dedicated visitor centres.

CERN *has a rich training programme for students at different levels, for postdoctoral scientists and other experienced researchers, for fellows and staff members, as well as for physics teachers. Most of these programmes are open also to participants from non-member states.*

At ***ESA****, training is related to user access by enhancing mobility and building capacities at the national level. ESA has placed an emphasis on increasing industrial capacity in the member states through programmes for trainers and trainees.*

EMBL *trains scientists at all levels and it restricts employment contracts to nine years to ensure that well-trained scientists return to its member states. It also organises many courses, workshops and conferences for scientists, science teachers and the public.*

ESRF *and* ***ILL*** *also train scientists at all levels. As at EMBL, few scientists are employed on a permanent basis, the majority being awarded five-year contracts. Postdoctoral scientists and PhD students have contracts of up to three years. In addition to staff training, the ESRF and the ILL participate in various training initiatives such as HERCULES.*[6]

EFDA-JET *trains scientists and engineers at all levels: in the associates' laboratories, on JET, at Summer Schools on fusion and by participating actively in a Goal Oriented Training Programme (GOTP) implemented under EFDA to assist EFDA Associates in recruiting and training young engineers in specific areas of fusion relevant to ITER construction.*

4.11 e-infrastructures

There are more than 50 countries from all over the globe currently connected to the European Grid infrastructure, serving some 200 Virtual Organisations and over 15,000 users from many scientific fields. The number of users is expected to grow and an increase is anticipated in the range of scientific communities using distributed computing infrastructures (e-infrastructures).

Long-term sustainability of distributed computing resources is essential for RIs that are currently using or plan to use the Grid. The development of the European e-infrastructure is also important for many new projects and major upgrades currently on the ESFRI Roadmap.

It is in the interest of many existing and new RIs and their scientific communities that a sustainable Grid infrastructure, as represented by the European Grid Initiative,[7] is maintained, and that the initiative attracts the continued support of the European Commission for the further development of distributed computing infrastructures in Europe.

[6] Higher European Research Course for Users of Large Experimental Systems (http://hercules.grenoble.cnrs.fr).

[7] http://web.eu-egi.eu/

***ESA**, **EFDA-JET**, and **CERN** in particular, rely on the GEANT network and the Grid infrastructure for the computing and data storage needed to support the research programmes of their communities.*

***EMBL** is involved in initiatives concerned with implementing standards for data exchange and integration procedures across biomedical institutions. EMBL-EBI also hosts the world's most extensive set of biomolecular data resources.*

***ESO** and **ESA** are involved with the Virtual Observatory, an effort to enable the interoperability of astronomical archives around the world and produce tools for their scientific exploitation. Both also participate in IVOA and the Euro-VO consortium. Its Science Archive hosts one of the biggest repositories of data obtained with ground-based telescopes.*

5. Forward look

RIs drive scientific excellence, and provide and enable world-leading research in the European Research Area. Expansion of European RI capacity, both in terms of quality and in the range of scientific disciplines, will serve Europe's aspiration to improve its competitive position in the world with regard to scientific achievement and economic performance.

The ESFRI process, together with the important role played by the European Commission and by the mobilisation of broad sections of the scientific community in recent years, has fostered the planning of future RIs by providing coordination and impetus to catalyse the discussion and preparation of more than 40 projects that aspire to become new European RIs or to continue to be world-class RIs. The realisation of any of these projects will require the concerted efforts of a broad range of stakeholders. Governments, ministries, European institutions and funding agencies, with the help of their scientific advisors at national and European levels, need to be involved in the prioritisation, preparation, construction and operation of present and new research facilities.

The preparatory phase funding made available by the European Commission under FP7 to support the ESFRI process has been very important in permitting diverse scientific communities to develop projects for new RIs and in enabling existing RIs to plan upgrade projects. In some cases, the work that has been made possible through this funding has already been decisive in obtaining approval to proceed with the project from present and future funding bodies.

Although the future of European RIs ultimately lies mainly in the hands of the EU member states, as does the future of European participation in global RIs, an active role of both the European Commission and the scientific community remains necessary. Realising new or upgrading RIs to complement existing RIs depends on their commitment and determination to identify and combine resources under the principle of "variable-geometry" and to engage in long-term planning. Therefore, creating, operating and achieving world-class excellence in the new European RIs requires concerted and sustained effort by all ERA stakeholders.

The EIROforum members have accumulated expertise and established good practice in establishing and maintaining world-class RIs. There is no single solution and different models and practices may be appropriate depending on the particular infrastructure. The EIROs already provide advice and support to a number of international projects and organisations in key technical and non-scientific fields, such as management, procurement and relations with industry. They now offer their collective expertise and experience to all those involved in the creation of new RIs, for the benefit of Europe and the further development of the European Research Area.

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The EIROforum is a collaboration between seven European intergovernmental scientific research organisations that are responsible for infrastructures and laboratories. As world leaders within their respective fields of science, the member organisations of the EIROforum constitute the vanguard of European science, enabling European scientists to engage in truly cutting-edge research and be competitive on a global scale. These organisations have a vital role to play in the future of European research.

The seven EIROforum members are:

CERN European Organisation for Nuclear Research

EFDA European Fusion Development Agreement

EMBL European Molecular Biology Laboratory

ESA European Space Agency

ESO European Organisation for Astronomical Research in the Southern Hemisphere

ESRF European Synchrotron Radiation Facility

ILL Institut Laue-Langevin